

Biometric Analysis of Olenellid Trilobites  
from the Pioche Formation (Lower Cambrian), Nevada

Senior Thesis

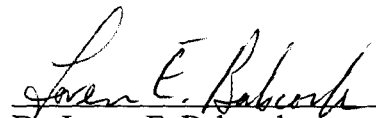
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## CONTENTS

Abstract.....	1
Introduction.....	2
Materials and Methods.....	3
Systematic Paleontology.....	9
Results.....	13
Conclusions.....	17
Acknowledgments.....	18
References.....	19

**ABSTRACT** – Eight species of olenellid trilobites are present in the Lower Cambrian C-shale member of the Pioche Formation in east-central Nevada. The three most abundant of them, *Olenellus (Olenellus) gilberti*, *Olenellus (Paedeumias) chiefensis*, and *Nephrolenellus geniculatus*, were used for biometric analysis. The three species can be differentiated quantitatively, as indicated by the graphs created in this project. The graphs indicate the differences among the three species based on the relative length of the glabella, width of the cephalon, shape of the glabella, and size of the eye ridges relative to the total cephalic length. According to the graphs, *O. (O.) gilberti* has a long glabella relative to the total cephalic length, and has large eye ridges. Most of the graphs of *O. (P.) chiefensis* show low slopes on regression lines compared to the other two species. The cephalic width of *O. (P.) chiefensis* is narrow relative to the total cephalic length and glabella, and the lateral glabellar segments are also narrow. The preglabellar field is wide. On the other hand, *N. geniculatus* has a wide cephalic length relative to the total cephalic length and glabella, and all lateral glabellar segments are wide relative to the size of the glabella. The eye ridges of *N. geniculatus* are considerably shorter than that of the other two species.

## INTRODUCTION

Olenellid trilobites are among the most characteristic and diverse fossils of siliciclastic lithofacies in the Lower Cambrian of Laurentia (the North America – Greenland paleocontinent). Recent restudy of the olenellids (particularly Palmer and Repira, 1993, 1997) has led to the recognition of 50 genus-level taxa, seven families, and two superfamilies. More than 80 species have been described. Because of their diversity and rapid evolution, olenellids are useful for cladistic analysis (Lieberman, 1988). Also, in some localities, they are common enough, and represented by enough growth stages, to be useful for ontogenetic analysis (Webster and Hughes, 1998).

The purpose of this thesis is to report on biometrical analyses performed on three co-occurring species of olenellids (Figure 1) from the informal C-shale member of the Pioche Formation (Lower Cambrian) of Ruin Wash, south-central Nevada. The locality that yielded specimens reported on here (Tables 1-3) is notable for the fact that it has yielded eight species of olenellid trilobites, some of which are new (A. R. Palmer, personal communication, 1998). The three species that are represented by the most numerous species are the subject of this thesis. They are *Olenellus (Olenellus) gilberti*, *Olenellus (Paedeumias) chiefensis*, and *Nephrolenellus geniculatus*. Following taxonomic identification of cephalae on a qualitative basis, measurements of specimens assigned to these three taxa were completed, and plots of numerical values were assembled in order to determine the extent to which these species can be distinguished quantitatively.



## MATERIALS AND METHODS

Sixty-one trilobite specimens were studied, of which forty-one cephalons were used in this biometrical study. They include 21 cephalons assigned to *O. (O.) gilberti*, 13 cephalons assigned to *O. (P.) chiefensis*, and seven cephalons assigned to *N. geniculatus* (Figure 1). Specimens were collected by Lloyd F. Gunther, the late Metta Gunther, and Val G. Gunther. Measurements were completed using an Optimas image analysis system. Microsoft Excel was used to create all the tables and graphs.

The procedure that I followed in this study is as follows. The first step was to classify specimens into species qualitatively. Qualitative classification emphasized characteristics such as length of the genal spines and eye ridges, shape and size of the glabella, width of the occipital ring and preglabellar field, and so forth. Species-level assignments were verified by L. E. Babcock and A. R. Palmer.

The second step involved measuring the cephalon. Where, possible, as many as seventeen measurements were performed per specimen. This process was done using an image analysis system equipped with Optimas software. Standard metrics (Shaw, 1957) together with some newly defined metrics, that were used are listed below. These metrics are keyed to Figures 2 and 3.

- A: Total cephalic length exclusive of genal spines – from the rear edge of the occipital ring to the front, center edge of cephalon
- B: Total glabellar length – from the deepest point in the occipital ring to the deepest point in the occipital furrow, in the sagittal plane
- C: Exsagittal palpebral length – between the ends of the palpebral lobes as projected into an exsagittal plane lying parallel to the sagittal plane
- C1: Palpebral chord length – directly from one end of the lobe to another without regard for the direction

- E: Sagittal width of the occipital lobe – from the deepest part of the occipital furrow to the near edge of the occipital lobe, both in the sagittal plane
- F: Sagittal width of cephalic frontal area – from the deepest part of the axial furrow to the front edge of the cephalon, both in the sagittal plane
- H: Sagittal width of the preglabellar area – from the deepest part of the axial furrow to the deepest part of the marginal furrow, both in the sagittal plane
- I: Maximum cephalic width – the transverse distance between parallel planes tangent to the outermost edges of the edge of the cephalon
- I2: Width between the genal angles – maximum width of the cephalon in front of the genal spines
- J1: Posterior cranial width – distance between inner edges of the genal spines
- J6: Width of posterolateral corner – distance between the inner edge of the genal spine and the geniculation along the posterior margin
- K: Transverse occipital length – width between the deepest parts of the axial furrow opposite the widest part of the occipital ring
- K2: Maximum glabellar width – width between imaginary lines normal to exsagittal planes through the deepest part of the axial furrow opposite the widest point of the glabella (can be anywhere along the length of the glabella)
- K3: Mid-occipital glabellar width – width between the deepest parts of the axial furrow opposite the mid-length of the glabella + occipital ring
- K6: Posterior width of L4 – width of L4 at intersection with the palpebral lobes
- K7: Mid-length width of L4 – width of L4 at 50 % of its sagittal length
- K8: Anterior width of L4 – width of L4 at 75 % of its sagittal length

After measurements were completed, all the data were exported to Microsoft Excel for further analysis. Scatterplots, together with regression lines, were then produced for the following metrics:

A vs. B – Total cephalic length vs. Total glabellar length

A vs. I2 – Total cephalic length vs. Occipital cephalic width

B vs. I2 – Total glabellar length vs. Occipital width

I2 vs. K6 – Occipital width vs. Posterior width of L4

B vs. K – Total glabellar length vs. Transverse occipital length

B vs. K2 – Total glabellar length vs. Maximum glabellar width

B vs. K3 – Total glabellar length vs. Mid-occipital glabellar width

B vs. K6 – Total glabellar length vs. Posterior width of L4

B vs. K7 – Total glabellar length vs. Mid-length width of L4

B vs. K8 – Total glabellar length vs. Anterior width of L4

A vs. C – Total cephalic length vs. Exsagittal palpebral length

A vs. C1 – Total cephalic length vs. Palpebral chord length

I2 vs. F – Occipital cephalic width vs. Sagittal width of cephalic frontal area

1



2



3

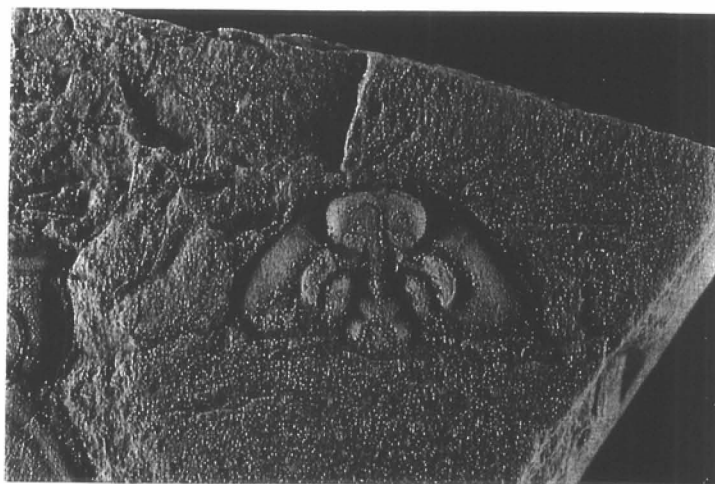


Figure 1 – Dorsal sides of olenellid trilobites from the Pioche Formation.

1 – *Olenellus (Olenellus) gilberti*, x2.

2 – *Olenellus (Paedeumias) chiefensis*, x1.5.

3 – *Nephrolenellus geniculatus*, x3.

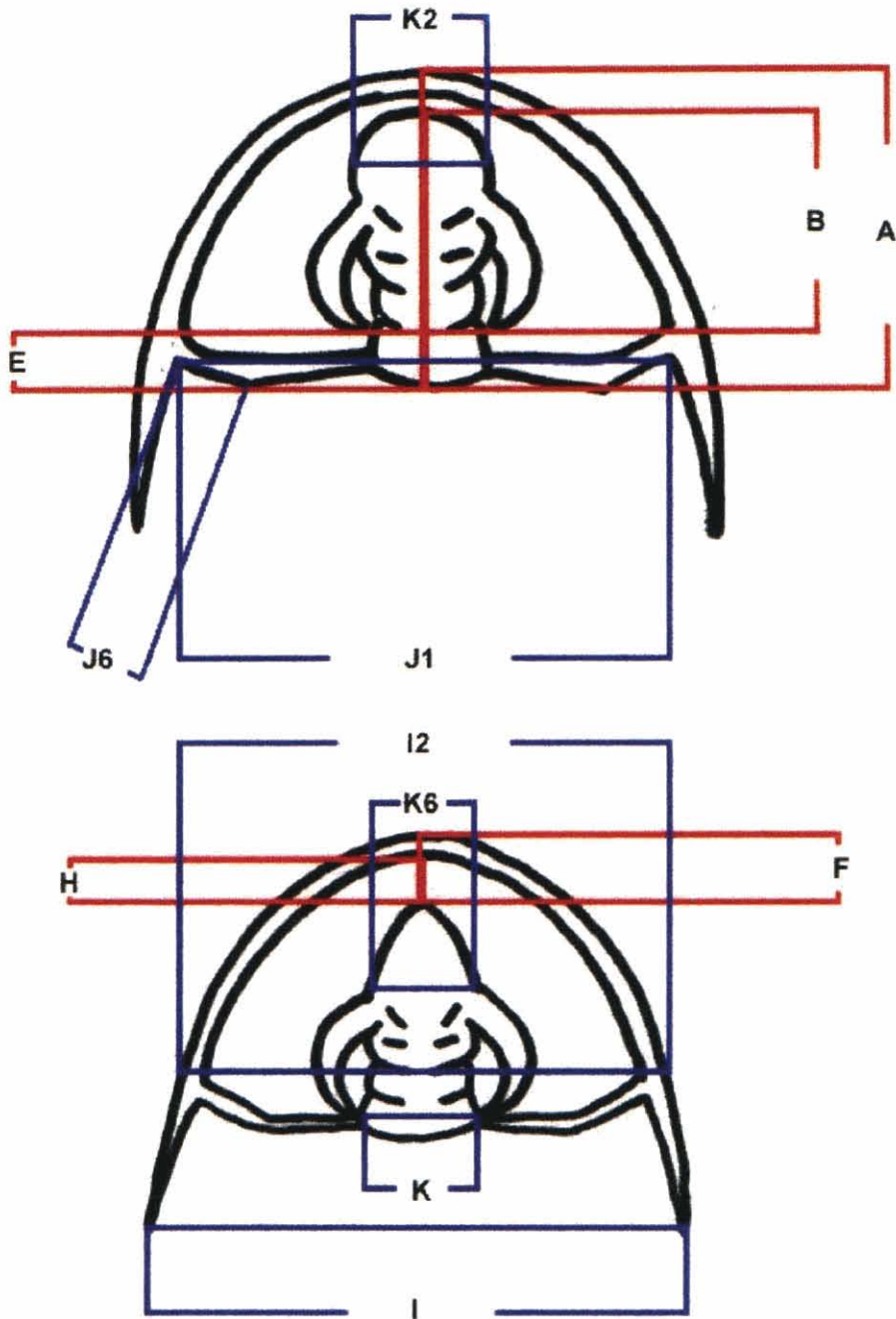


Figure 2 – Schematic diagrams showing measurements of the cephalon of olenellid trilobites (top – *Olenellus (Olenellus) gilberti*, bottom – *Olenellus (Paedeumias) chiefensis*).

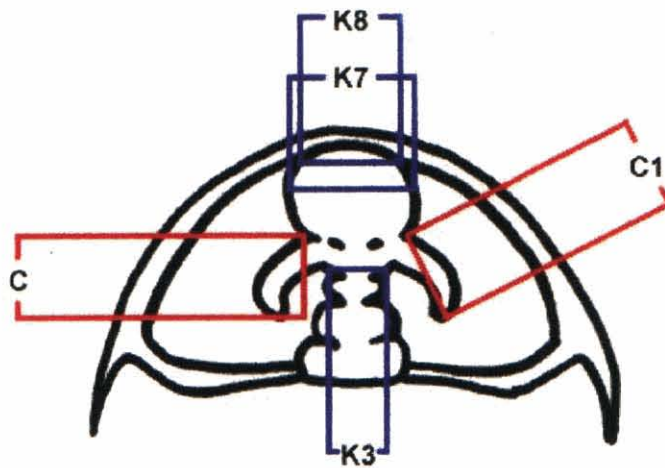


Figure 3 - Schematic diagram showing measurements of the cephalon of olenellid trilobite (*Nephrolenellus* *geniculatus*).

## SYSTEMATIC PALEONTOLOGY

Class TRILOBITA Walch

Order REDLICHIIIDA Richter

Suborder OLENELLINA Walcott

Superfamily OLENELLOIDEA Walcott

Family OLENELLIDAE Walcott, 1890

Subfamily OLENELLINAE Walcott, 1890

Genus OLENELLUS Hall, 1861

*Diagnosis* (modified from Palmer and Repina, 1997, p. 408). – External surface generally smooth or with faint terrace lines, rarely granular or reticulate. Occipital ring smooth or with small node near posterior margin; occipital spine rare; genal spine angle opposite or posterior to L1; genal spine slender.

Subgenus OLENELLUS (OLENELLUS) Hall, 1862

*Type species.*– *Olenellus thompsoni* Hall, 1859, p. 59.

*Diagnosis* (modified from Palmer and Repina, 1997, p. 408). – Genal spines at posterolateral cephalic corners or slightly advanced to position opposite L1; intergenal spines, if present, small, close to genal spines, and directed slightly posterolaterally. Preglabellar field absent or very short, length (sag.) usually less than twice length (sag.) of anterior border; ocular lobe curved, its posterior tip convergent toward glabella and situated opposite or posterior to posterior part of L1; S2 isolated from axial furrow, usually present as distinct transverse slit.

## OLENELLUS (OLENNELUS) GILBERTI Meek, 1873

### Figure 1.1

*Discussion.* – *Olenellus (Olenellus) gilberti* seems to be the most abundant species in the C-shale member of the Pioche Formation. The genal spines are relatively long. The preglabellar field is so short, and it can be barely measured. Width through the anterior end of the glabella and the occipital ring (glabellar segments) is constant. The eye ridges are long but do not extend to the posterior border.

## Subgenus OLENELLUS (PAEDEUMIAS) Walcott, 1910

*Type species.* – *Paedeumias transitans* Walcott, 1910, p. 305 – 310.

*Diagnosis* (modified from Palmer and Repina, 1997, p. 408). – Posterior margin of cephalon nearly straight or only slightly angled forward distal to position of intergenal spines; intergenal spine or swelling generally closer to genal spine than to axial furrow. Length (sag.) of preglabellar field greater than twice length (sag.) of anterior border; posterior tip of palpebral lobe convergent toward glabella, opposite or posterior to posterior part of L1.

## OLENELLUS (PAEDEUMIAS) CHIEFENSIS Palmer, in press.

### Figure 1.2

*Discussion.* – The most distinctive characteristic of this species is the forward tapering (pointed) shape of the fourth glabellar lobe (L4). Other species usually have a rounded anterior margin on L4. The genal spines are long. The preglabellar field is wider than that of other species found in the same formation. The eye ridges extend to the posterior



border. Another important character of *O. (P.) chiefensis* is the presence of a narrow preglabellar ridge (Figure 1.2).

Subfamily BRISTOLIINAE Palmer & Repina, 1993

*Diagnosis* (modified from Palmer and Repina, 1997, p. 409). – Glabella usually strongly constricted at S1 or L2; width (tr.) of anterior part of L1 usually distinctly narrower than occipital ring; glabellar furrows generally well developed. Preglabellar field shorter (sag.) than anterior border or absent. Posterior tip of ocular lobe opposite or anterior to L1. Third thoracic segment with inner part of pleural region strongly expanded distally; pleural spine may be extended posterior to end of thorax. Opisthothorax well developed. Pygidium not known

Genus NEPHROLENELLUS Palmer & Repina, 1993

*Type species.*– *Olenellus multinodus* Palmer in Palmer and Halley, 1979, p. 72 – 73.

*Diagnosis* (modified from Palmer and Repina, 1997, p. 411). – Posterior margin of cephalon directed slightly posterolaterally to intergenal spine or intergenal swelling that is situated near slightly advanced genal spine. Preglabellar field short (sag.); width of interocular area approximately half or more width of glabella at L2; posterior tip of ocular lobe opposite L1. Third thoracic segment macropleural, having extremely long pleural spine with tip posterior to end of thorax; prothorax of 13 segments; opisthothorax of at least 17 segments; 15th segment lacking strong axial spine.

## NEPHROLENELLUS GENICULATUS Palmer, in press

Figure 1.3

*Discussion.* – The most significant difference between *N. geniculatus*, and the other two species treated here, (*O. (O.) Gilberti* and *O. (P.) chiefensis*), is the size of the fourth glabellar lobe (L4). The fourth glabellar lobe of *N. geniculatus* is considerably larger, and it occupies all the preglabellar field. The genal spines are short. The interocular areas are wide. The third glabellar segment is the narrowest among them. The preglabellar field is missing because of the extremely large L4, which extends to the anterior border.

## RESULTS

Thirty-eight bivariate graphs have been created from the data collected on the trilobite cephalons (Figures 4 – 41). Each set of graphs has equal intervals for both the x-axis and the y-axis so that three species can be easily compared.

A vs. B – A graph of *O. (P.) chiefensis* has the lowest slope to the regression line of A vs. B. It indicates that glabellar length relative to the maximum cephalic length (A) is much shorter than that of the other two species. In other words, the preglabellar area of *O. (P.) chiefensis* is largest among the taxa studied. However, the slope value of *O. (O.) gilberti*, which has larger preglabellar area than that of *N. geniculatus*, is higher than that of *N. geniculatus*. It is because *N. geniculatus* has relatively shorter maximum cephalic length.

A vs. I2 – I2, rather than I, was used for regression analysis because many of the specimens lack the genal spines. I cannot be measured without the genal spines. Graphs of A vs. I2 indicate the overall shape of the cephalon. If the slope of regression is close to 2, the shape of the cephalon is more semicircular. According to the slopes of the graphs, the cephalon shape of *O. (P.) chiefensis* is close to semicircular, and that of *N. geniculatus* is more like a semi-elliptical figure.

B vs. I2 – Compared to the previous graph, A vs. I2, the slopes of all B vs. I2 graphs are larger because B is always smaller than A. *O. (P.) chiefensis*, which has wider preglabellar area, shows a smaller B and the lowest slope. On the other hand, *N. geniculatus*, which has a relatively large glabella, shows the highest inclination slope.

I2 vs. K6 – I2 vs. K6 graphs show the proportion of K6 to the width of the cephalon, I2. *N. geniculatus*, which has the largest L4, also has a more rounded L4 than both *O. (O.) gilberti* and *O. (P.) chiefensis*. *O. (O.) gilberti* has the largest relative value of K6. *O. (P.) chiefensis*, which has the smallest L4, has the narrowest K6.

B vs. K – *Olenellus (Paedeumias) chiefensis* shows the lowest slope of a graph of B vs. K. It suggests that the proportional width of the occipital ring to length of the glabella is small. The occipital ring of *N. geniculatus* is not much larger than that of the other two species, but proportionally it actually has the widest occipital ring of these species studied.

B vs. K2 – K2 is measured at various points of the glabella because K2 is the widest area of the glabella, and the three species have their widest areas at different points. For example, *O. (O.) gilberti* and *N. geniculatus* usually have the widest point of the glabella at the fourth glabellar lobe (L4). However, the widest point of the glabella of *O. (P.) chiefensis* is adjacent to occipital ring.

B vs. K3 – K3 is measured at 50 % of the length between the anterior end of the glabella and the occipital ring. The K3 value for *N. geniculatus* is missing because it was extremely difficult to determine where the half way length point was located. *O. (P.) chiefensis* has larger K3 values than does *O. (O.) gilberti*.

B vs. K6 – B vs. K6, B vs. K7, and B vs. K8 graphs express the L4 shape which is one of the most important distinguishing characteristics of the three studied species. Larger slopes of the regression lines indicate that the eyes are wider apart. The inclination of *N. geniculatus* is almost equal to 1, which means B and K6 are about the same length. *O. (P.) chiefensis* has much smaller B values (almost one half of the

glabellar length). *O. (O.) gilberti* has intermediate widths of K6 relative to the glabellar length.

B vs. K7 – K7 is measured at 50 % of the length between the anterior end of the glabella and the line of K6. K7 values could be very close to K2, the widest point of the glabella, in some cases. The B vs. K7 graph is the single most useful metric relationship for determining the differences among the three species. If the shape of L4 is round, then K7 should be larger than K6. Only *O. (P.) chiefensis* shows a drastic decrease from K6 to K7. It means that the L4 of *O. (P.) chiefensis* tapers off, and is pointed anteriorly. On the other hand, the K7 of *N. geniculatus* is larger than K6. It suggests that the L4 of *N. geniculatus* is expanded.

B vs. K8 – As explained above, the overall shape of the fourth glabellar lobe can be examined by comparing values K6, K7 and K8. A smaller K8 value means that the L4 glabellar lobe is narrower toward the anterior end. The B vs. K8 graph is one of the most useful graphs for determining differences among the three studied species. The slope of *O. (P.) chiefensis* is considerably smaller than that of *N. geniculatus*. The large K8 values of *N. geniculatus* indicate that the shape of the fourth lobe is large and round. The small K8 values of *O. (P.) chiefensis* are related to the pointed L4 of the species.

A vs. C – *N. geniculatus*, which has the shortest palpebral length (exsag.), shows the smallest slope when compared to the maximum glabellar length (A). The eyes of *N. geniculatus* are short and expanded half way to the posterior border. According to the schematic diagrams and figures, *O. (P.) chiefensis* seems to have longer eyes than does *O. (O.) gilberti*; however, in fact, the slope of *O. (O.) gilberti* is greater.

A vs. C1 – Discussion related to A vs. C is relevant to A vs. C1 as well. C and C1 both measure eye length, although they do so in different directions.

I2 vs. F – I2 vs. F graphs seem to be the most difficult ones to analyze because the plots have a wide scatter, and the lower R-square values compared to other graphs indicate less accuracy. When it comes to F, there are a few possibilities that could have created some errors. First of all, F is the shortest length measurement used in this project (H could be smaller in some cases, but *N. geniculatus* lacks H and is not used in graphs). Slight mistakes in measuring could have created larger errors. Secondly, distortion of the specimens could seriously affect small measurements.

## CONCLUSIONS

The three most abundant species, *O. (O.) gilberti*, *O. (P.) chiefensis*, and *N. geniculatus*, found in the Pioche Formation, have characters that help to distinguish them from each other. In order to determine the differences, both qualitative analysis and quantitative analysis were used in this project.

Length of the glabella of the three species appears to be various. It seems that the glabellar length of *N. geniculatus* is long, and that of *O. (O.) chiefensis* is short. However, qualitative analysis shows that the glabella length of the three species is not as different as they appear. K6 also looks different, but the graphs indicate that the three species have similar K6 widths relative to their cephalic width. *N. geniculatus* has an extremely large, rounded L4; *O. (P.) chiefensis* has a short, pointed L4; and *O. (O.) gilberti* has an intermediate L4 size. Graphs also show the various differences in slopes, which are related to the shape of the L4. Thus, the shape of L4 is the most essential factor to determine the three species. Although the eye shapes of *O. (O.) gilberti* and *O. (P.) chiefensis* are difficult to distinguish, the eye length of *N. geniculatus* is much shorter than the other two species. Therefore, the size of eye ridges is of secondary importance for classification.

## **ACKNOWLEDGMENTS**

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Figure 4 – Bivariate plot of measurements A vs. B for *Olenellus (Olenellus) gilberti*.

Figure 5 – Bivariate plot of measurements A vs. I2 for *Olenellus (Olenellus) gilberti*.

Figure 6 – Bivariate plot of measurements B vs. I2 for *Olenellus (Olenellus) gilberti*.

Figure 7 – Bivariate plot of measurements I2 vs. K6 for *Olenellus (Olenellus) gilberti*.

Figure 8 – Bivariate plot of measurements B vs. K for *Olenellus (Olenellus) gilberti*.

Figure 9 – Bivariate plot of measurements B vs. K2 for *Olenellus (Olenellus) gilberti*.

Figure 10 – Bivariate plot of measurements B vs. K3 for *Olenellus (Olenellus) gilberti*.

Figure 11 – Bivariate plot of measurements B vs. K6 for *Olenellus (Olenellus) gilberti*.

Figure 12 – Bivariate plot of measurements B vs. K7 for *Olenellus (Olenellus) gilberti*.

Figure 13 – Bivariate plot of measurements B vs. K8 for *Olenellus (Olenellus) gilberti*.

Figure 14 – Bivariate plot of measurements A vs. C for *Olenellus (Olenellus) gilberti*.

Figure 15 – Bivariate plot of measurements A vs. C1 for *Olenellus (Olenellus) gilberti*.

Figure 16 – Bivariate plot of measurements I2 vs. F for *Olenellus (Olenellus) gilberti*.

Figure 17 – Bivariate plot of measurements A vs. B for *Olenellus (Paedeumias)*  
*chiefensis*.

Figure 18 – Bivariate plot of measurements A vs. I2 for *Olenellus (Paedeumias)*  
*chiefensis*.

Figure 19 – Bivariate plot of measurements B vs. I2 for *Olenellus (Paedeumias)*  
*chiefensis*.

Figure 20 – Bivariate plot of measurements I2 vs. K6 for *Olenellus (Paedeumias)*  
*chiefensis*.

Figure 21 – Bivariate plot of measurements B vs. K for *Olenellus (Paedeumias)*  
*chiefensis*.

Figure 22 – Bivariate plot of measurements B vs. K2 for *Olenellus (Paedeumias) chiefensis*.

Figure 23 – Bivariate plot of measurements B vs. K3 for *Olenellus (Paedeumias) chiefensis*.

Figure 24 – Bivariate plot of measurements B vs. K6 for *Olenellus (Paedeumias) chiefensis*.

Figure 25 – Bivariate plot of measurements B vs. K7 for *Olenellus (Paedeumias) chiefensis*.

Figure 26 – Bivariate plot of measurements B vs. K8 for *Olenellus (Paedeumias) chiefensis*.

Figure 27 – Bivariate plot of measurements A vs. C for *Olenellus (Paedeumias) chiefensis*.

Figure 28 – Bivariate plot of measurements A vs. C1 for *Olenellus (Paedeumias) chiefensis*.

Figure 29 – Bivariate plot of measurements I2 vs. F for *Olenellus (Paedeumias) chiefensis*.

Figure 30 – Bivariate plot of measurements A vs. B for *Nephrolenellus geniculatus*.

Figure 31 – Bivariate plot of measurements A vs. I2 for *Nephrolenellus geniculatus*.

Figure 32 – Bivariate plot of measurements B vs. I2 for *Nephrolenellus geniculatus*.

Figure 33 – Bivariate plot of measurements I2 vs. K6 for *Nephrolenellus geniculatus*.

Figure 34 – Bivariate plot of measurements B vs. K for *Nephrolenellus geniculatus*.

Figure 35 – Bivariate plot of measurements B vs. K2 for *Nephrolenellus geniculatus*.

Figure 36 – Bivariate plot of measurements B vs. K6 for *Nephrolenellus geniculatus*.

Figure 37 – Bivariate plot of measurements B vs. K7 for *Nephrolenellus geniculatus*.

Figure 38 – Bivariate plot of measurements B vs. K8 for *Nephrolenellus geniculatus*.

Figure 39 – Bivariate plot of measurements A vs. C for *Nephrolenellus geniculatus*.

Figure 40 – Bivariate plot of measurements A vs. C1 for *Nephrolenellus geniculatus*.

Figure 41 – Bivariate plot of measurements I2 vs. F for *Nephrolenellus geniculatus*.

Table 1

O. (O.) gilberti	A	B	C	C1	E	F	H	I	I2	K	K2	K3	K6	K7	K8	J1	J2
1	9.88	7.85	5.11	5.12	0.79	1.05	0.46	26.3	24.6	5.12	6	5.2	6.15	6.08	5.28	21.8	2.89
2	11.08	8.87	5.99	5.92	1.18	1.31	0.55	28.57	25.86	5.04	7.32	5.63	7.15	7.32	6.64	24.12	3.35
3	19.28	15.48	9.21	9.59	2.7	1.23	0	49.5	47.14	9.9	11.7	9.3	11.71	11.4	10.05	42	6.31
4	6.62	5.16	3.27	3.3	0.62	0.96	0.58	16.39	15.12	3.15	3.81	3.43	3.81	2.83	2.07	13.65	2.08
5	6.71	5.01	3.27	3.26	0.85	1.01	0.63	16.49	15.21	3.11	3.76	3.36	3.8	3.46	2.52	13.63	1.92
6	6.44	4.68	3.34	3.37	0.97	0.84	0.59	16.95	15.4	3.01	3.58	3.3	3.62	3.18	2.42	13.85	1.73
7	8.3	6.02			1.03	1.26	0.68	17.39	16.57							14.56	1.77
8	7.1	5.34	3.65	3.64	0.93	1.09	0.55	17.42	16.24	3.38	3.8	3.48	3.71	3.47	2.71	14.48	1.91
9	4.62	3.51	2.34	2.33	0.45	0.68	0.42	11.48	9.76	2.33	2.4	2.2	2.41	1.99	1.5	9.27	1.49
10	4.93	3.87	2.42	2.47	0.51	0.54	0.2	12.38	11.52	2.24	2.43	2.32	2.43	2.1	1.66	10.5	1.17
11	10.23	8.13	4.61	4.79	0.9	1.03	0.4	23.9	23.12	4.82	5.15	5.25	5.15	4.1	3.07	20.05	2.93
12		5.45	3.6	3.7		0.91	0.52		16.24	3.39	3.78		3.78	3.43	2.68	14.9	2.31
13	5.48	4.13	2.67	2.72	0.77	0.53	0.35		11.58	2.43	2.78	2.46	2.78	2.2	1.55	10.46	1.39
14			4.79	4.87		1.45	0.84	26.2	24.4		5.79		5.79	4.93	4.07	22	2.52
15	5.79	4.24	2.74	2.78	0.75	0.81	0.4		12.81	2.63	3.19	2.73	3.19	2.88	2.34	12.77	1.31
16	9.2	7.07	4.38	4.4	1.14	1.02	0.54		21.6	4.34	4.66	4.45	4.66	4.03	3.16	20.06	2.87
17	6.61	5.06	3.38	3.4	0.77	0.74	0.35		14.51	3.22	3.61	3.26	3.61	2.86	1.96	13.3	1.89
18	5.6	4.19	3.03	3.2	0.59	0.77	0.42	14.31	12.83	2.59	2.93	2.71	2.93	2.15	1.55	11.41	1.97
19	7.45	5.67	3.61	3.63	0.73	1.23				3.35	4.58	4.08	4.58	3.85	2.91		
20						0.71	0.43		14.97		3.6		3.6	2.96	1.99	13.85	2.2
21	4.24	3.1	2.36	2.37	0.47	0.67	0.37		9.4	1.88	2.06	1.91	2.06	1.73	1.18	8.98	1.33

Table 2

<i>O. (P.) chiefensis</i>	A	B	C	C1	E	F	H	I	I2	K	K2	K3	K6	K7	K8	J1	J2
1	4.45	3.09	2.21	2.27	0.45	0.88			7.71	1.69	1.69		1.44	1.03	0.67	6.99	1.15
2	11.57	8.25	5.46	5.72	1.1	2.3	1.94		21.97	5.03	5.03		4.02	2.96	2.21	19.89	2.99
3		8.19				2.09	1.49		25.76				5.6	3.66	2.11	23.38	3.17
4	8.09	4.71	3.65	3.7	0.75	2.63	2.36		14.71	3.21	3.21	2.91	3.05	2.09	1.45	14.12	1.73
5	8.05	4.47	3.59	3.61	0.75	2.83	2.36		15.04	3.25	3.25	3.08	3.12	2.24	1.54		
6	6.37	4.34	2.95	3.02	0.72	1.29	1.17		11.05	2.54	2.54		2.23	1.38	0.86	9.84	1.47
7			2.42	2.65		0.67	0.41		10.2	2.61	2.61		2.3	1.54	0.93	9.57	1.23
8	7.51	5.47	3.41	3.61	0.63	1.34	1.03		14.05	3.35	3.35		2.69	1.98	0.99	13.05	1.69
9	10.43	7.1	4.58	4.87	0.76	2.5	2.01		19.73	4.49	4.49		3.64	2.88	1.99	18.37	3.07
10		5.04	3.64	3.83	0.63					3.08	3.08		2.55	1.79	1.21		
11						1.25	0.93						2.17	1.53	0.83		
12			4.64	4.91	1.15				18.55	4.83	4.83		3.72			17.09	2.68
13	10.34	7.93	4.62	4.9	1.02	1.54	0.88		17.34	4.16	4.16		3.59	2.5	1.58	16.43	2.56

Table 3

<i>N. geniculatus</i>	A	B	C	C1	E	F	H	I	I2	K	K2	K3	K6	K7	K8	J1	J2
1	4.9	4.03	1.64	2.07	0.59	0.32	0		12.22	2.48	3.75		3.08	3.63	3.18	11.49	1.45
2	3.81	3.08	1.29	1.5	0.47	0.25	0		9.71	1.91	3.08		2.49	2.97	2.44	8.8	1.1
3			1.55	1.88	0.49		0		11.52	2.34	3.45		2.54				
4	3.76	3.17	1.38	1.59	0.41	0.15	0		9.45	1.8	3.09		2.14	3.09	2.77	9.02	0.95
5	2.72	2.28	1.03	1.21	0.26	0.15	0		6.06	1.28	1.74		1.45	1.84	1.61	5.5	0.7
6	2.79	2.3	1.14	1.32	0.37	0.12	0		7.25	1.4	2.13		1.42	2.09	1.69	6.78	0.75
7			1.9	2.23	0.45	0.3	0		11.76	2.15	3.67		3.01	3.67	3.07	11.04	1.41



Figure 4

A vs. B

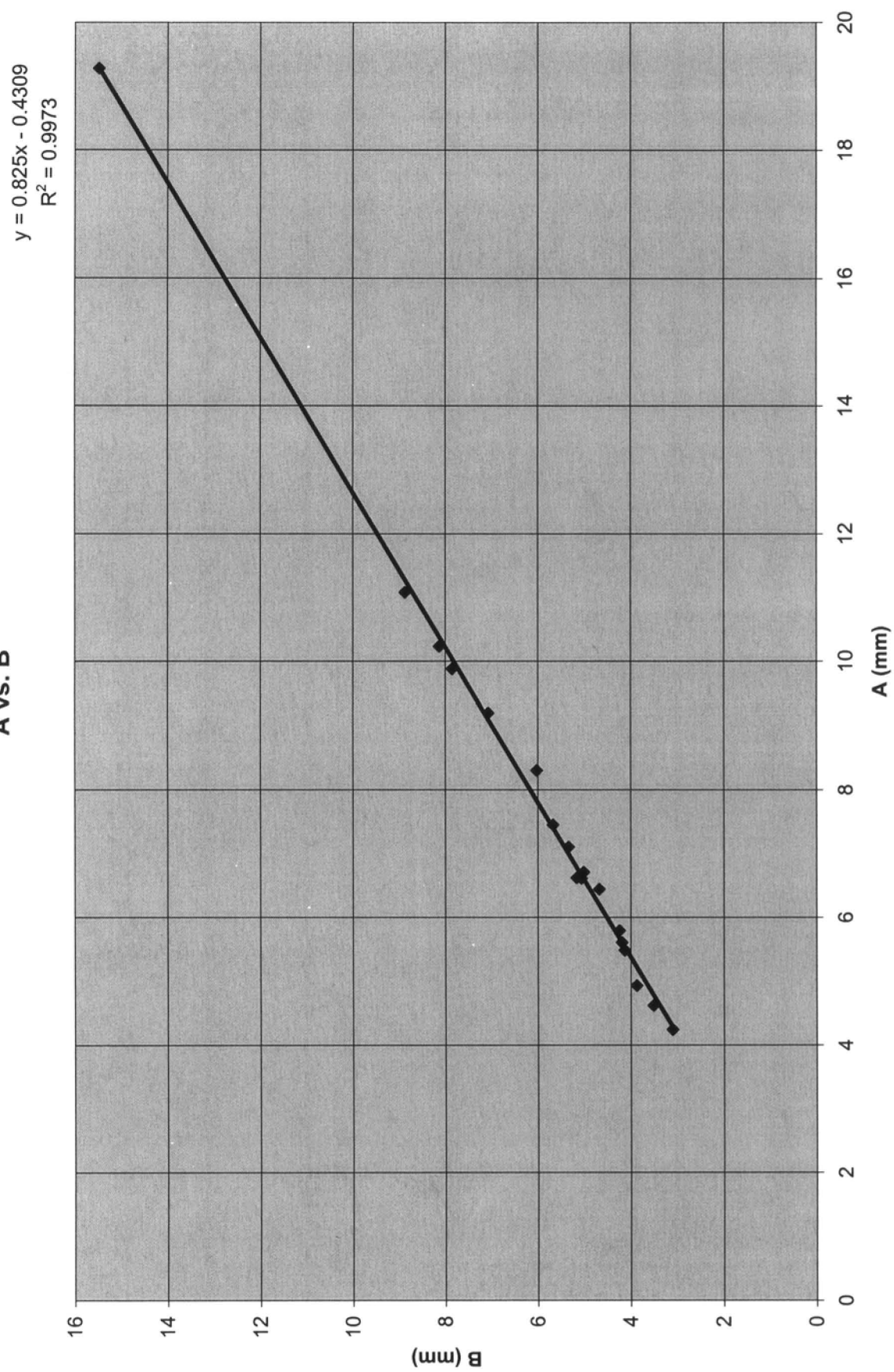


Figure 5

A vs. I2

$$y = 2.5083x - 1.6528$$
$$R^2 = 0.9906$$

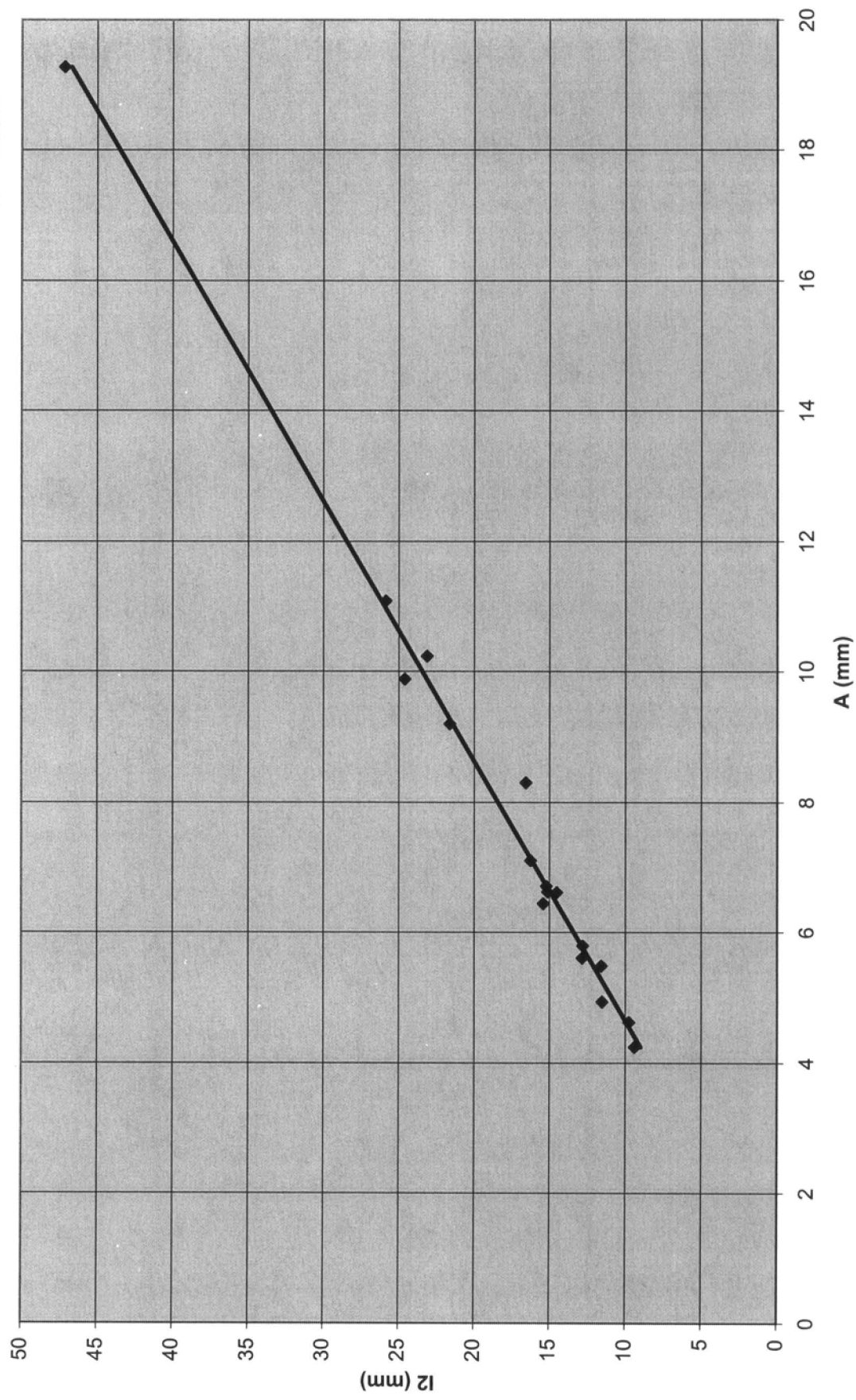


Figure 6

**B vs. I2**

$$y = 3.0396x - 0.3453$$
$$R^2 = 0.9927$$

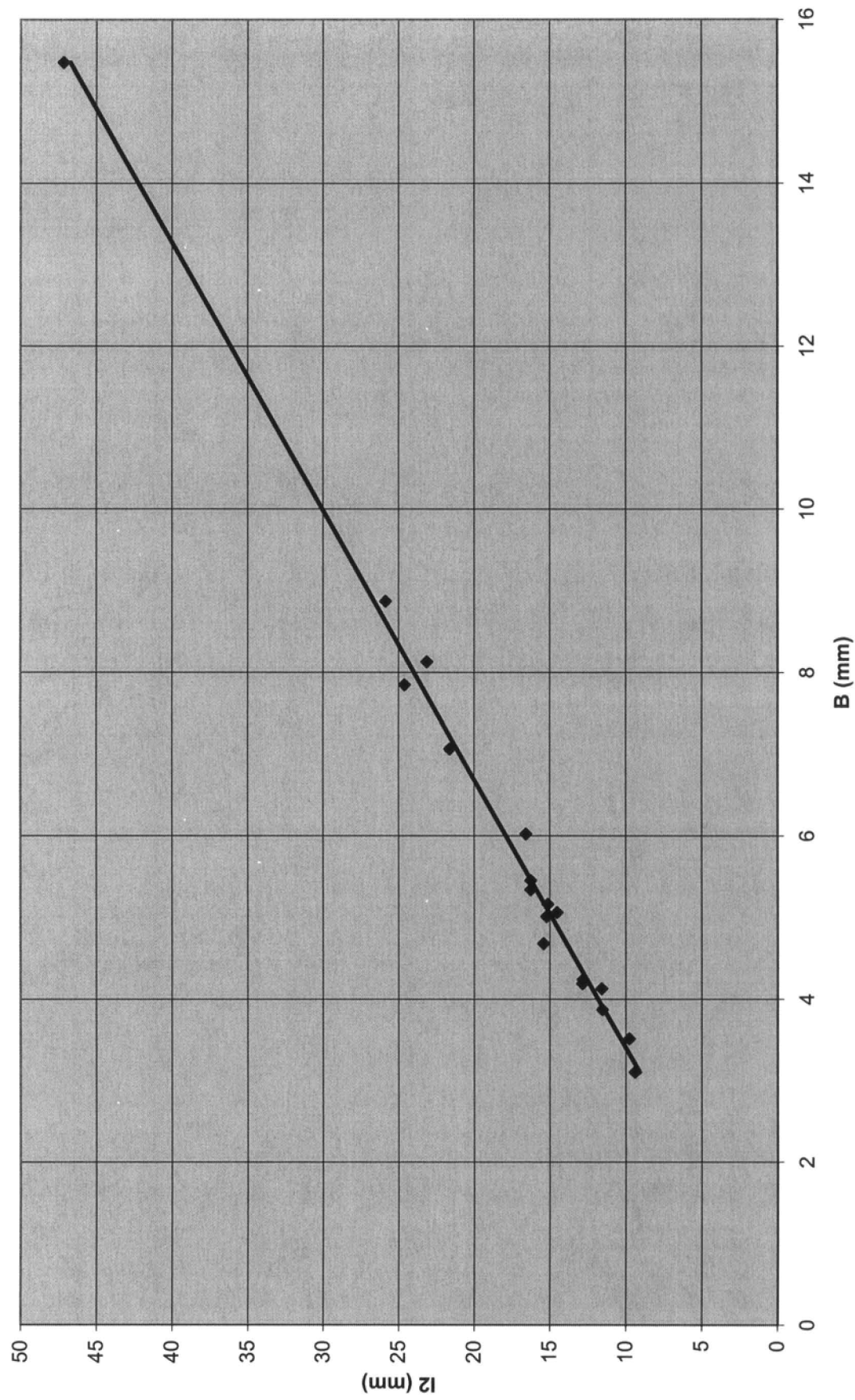


Figure 7

I2 vs. K6

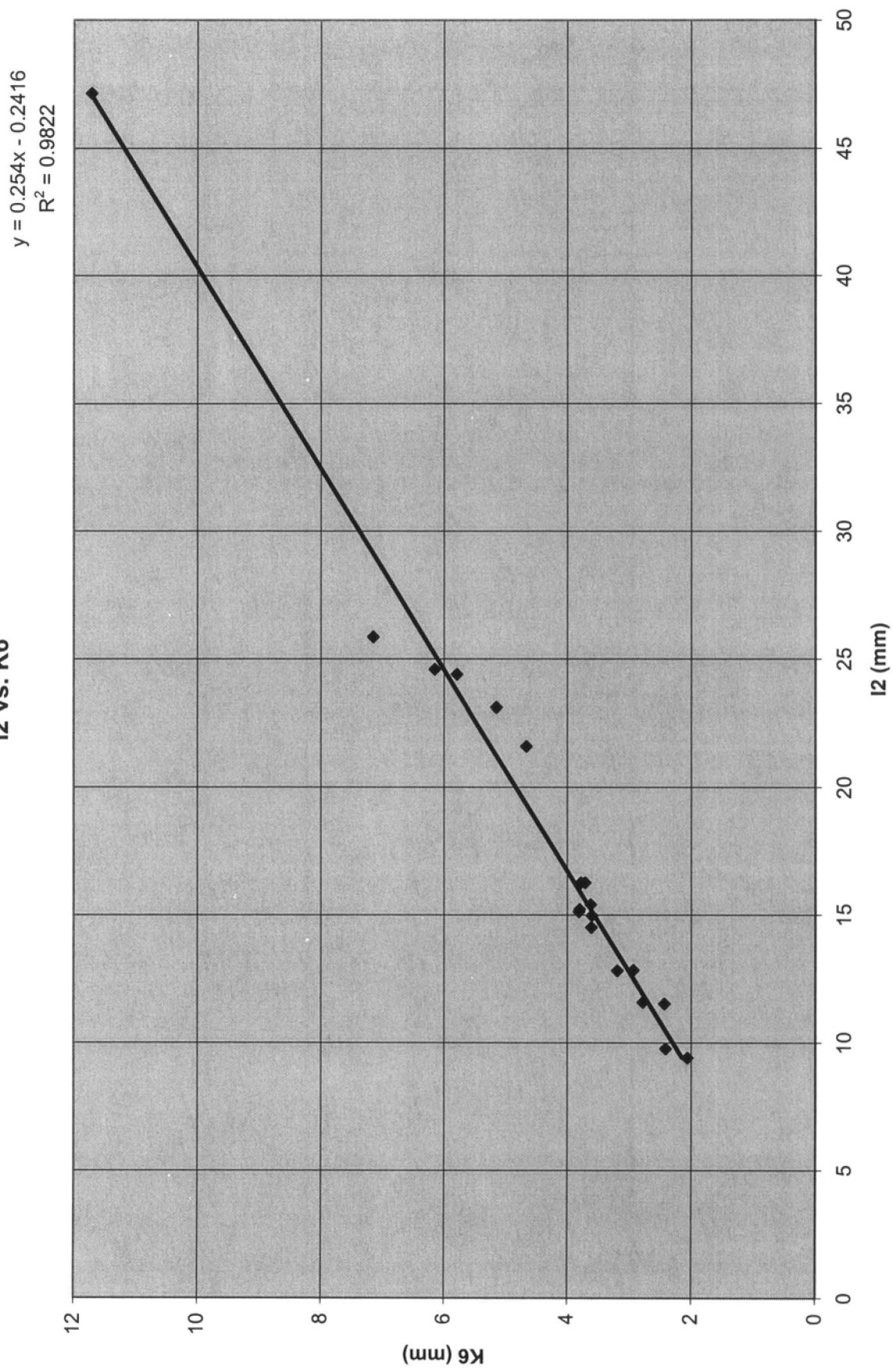




Figure 8

B vs. K

$y = 0.6316x - 0.0849$   
 $R^2 = 0.991$

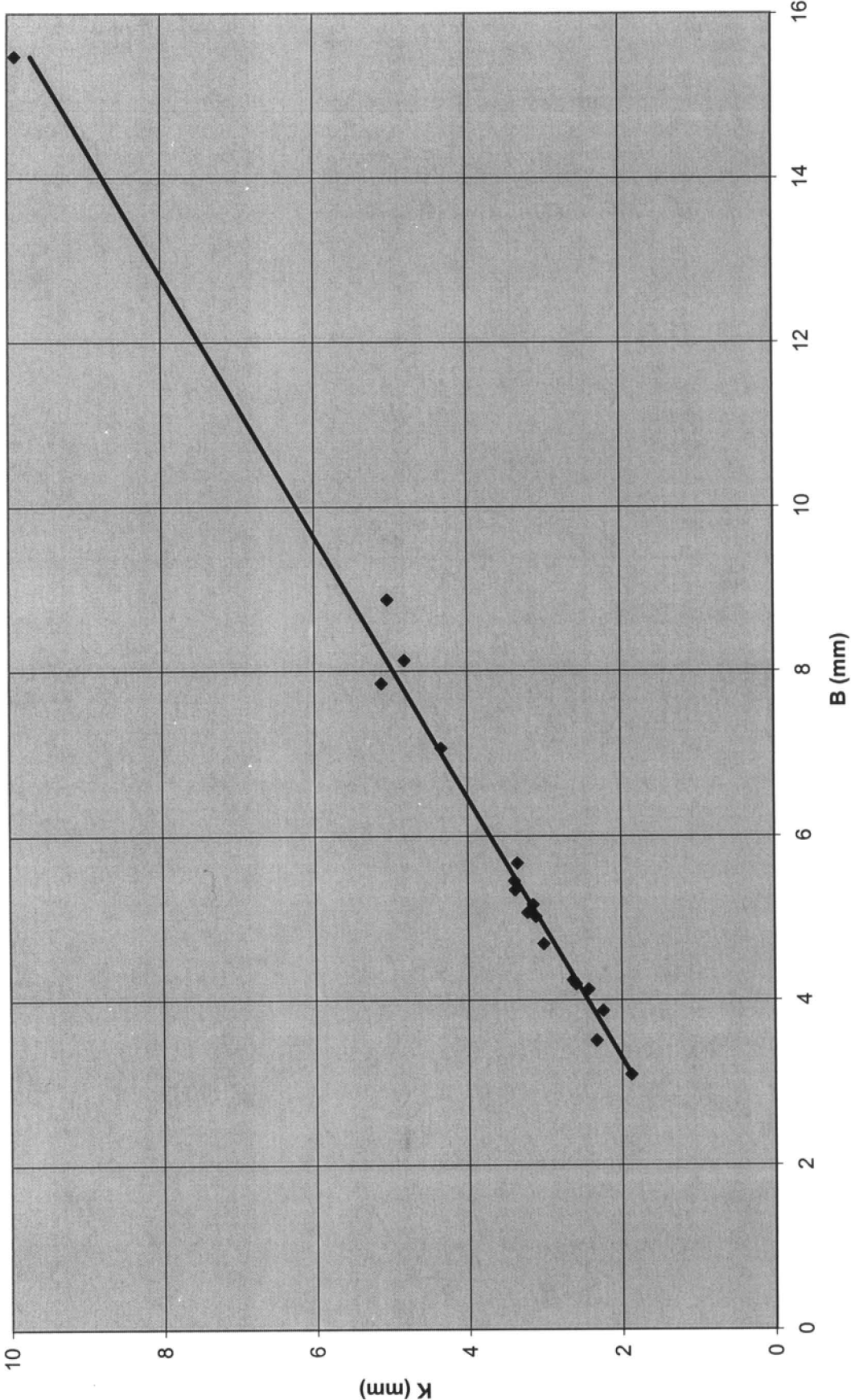


Figure 9

**B vs. K2**

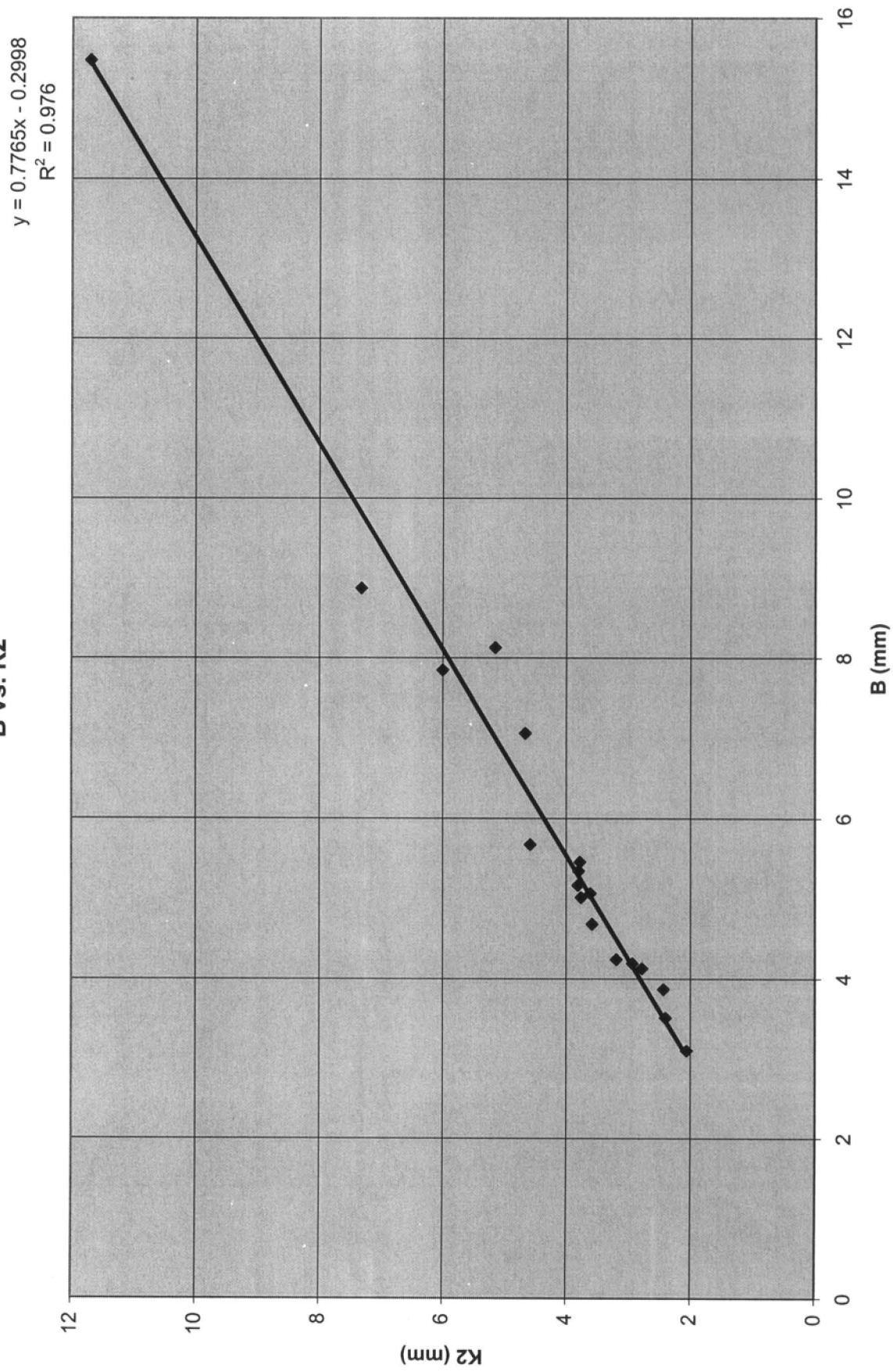


Figure 10

**B vs. K3**

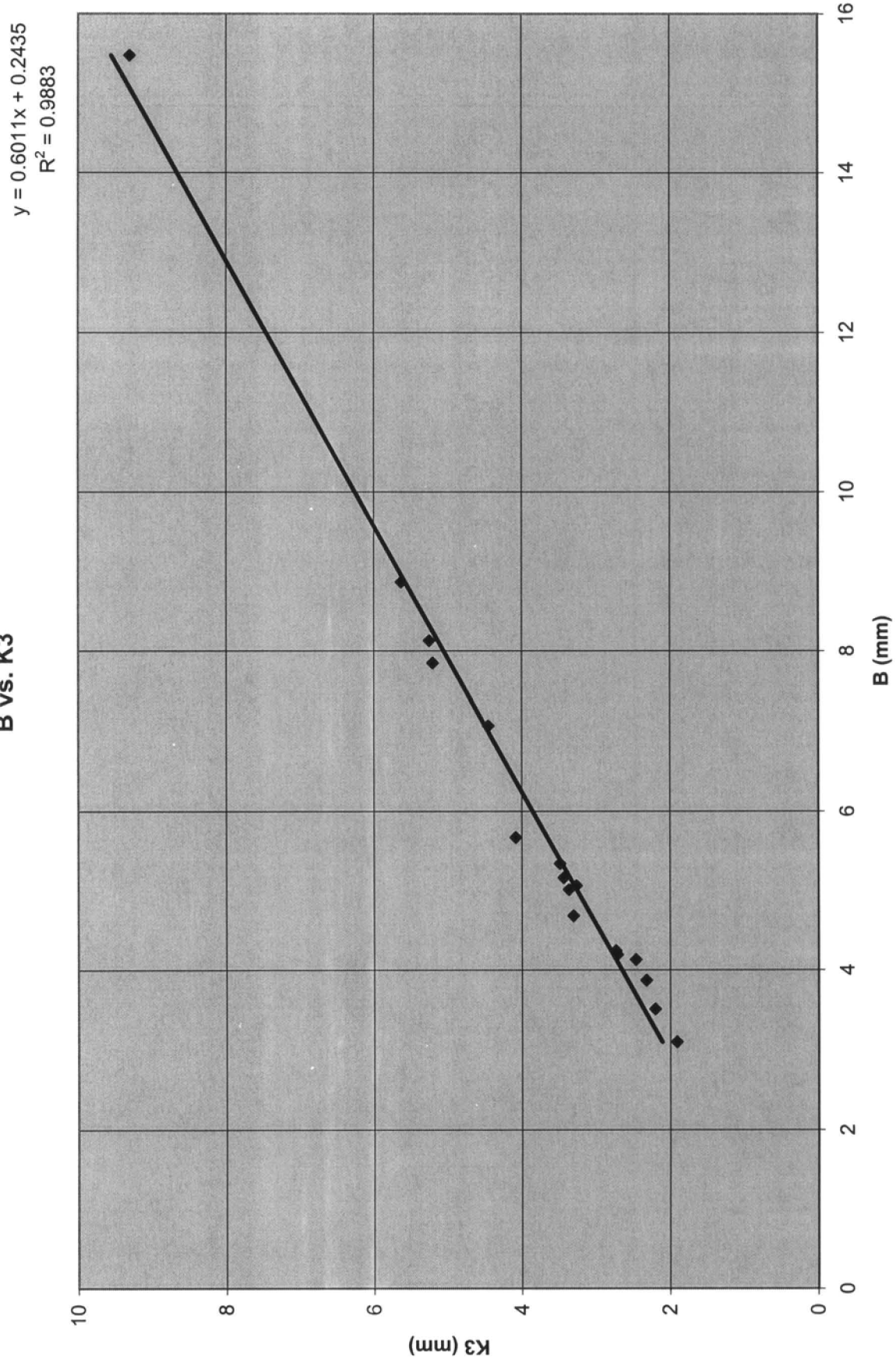


Figure 11

**B vs. K6**

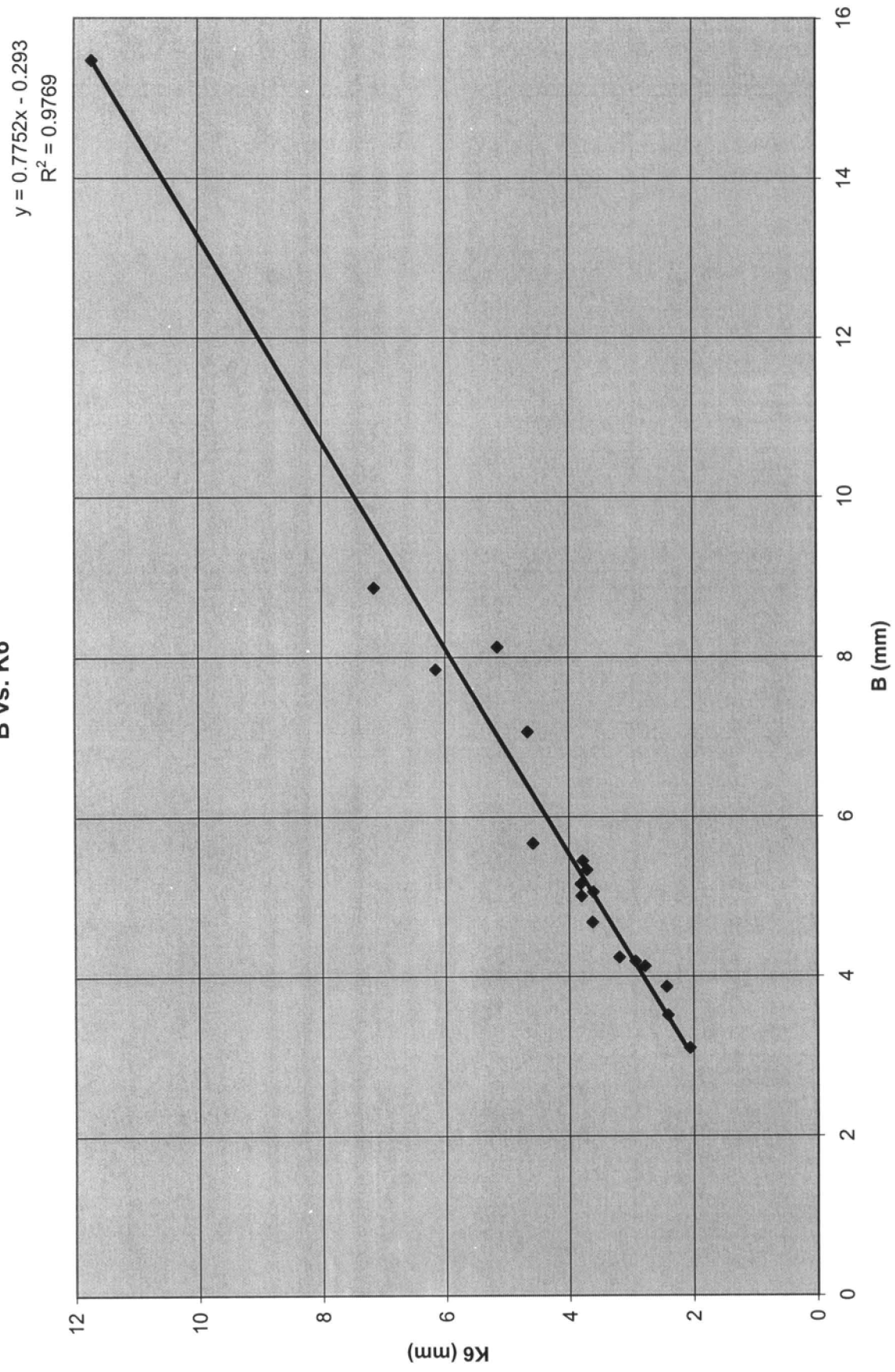




Figure 12

**B vs. K7**

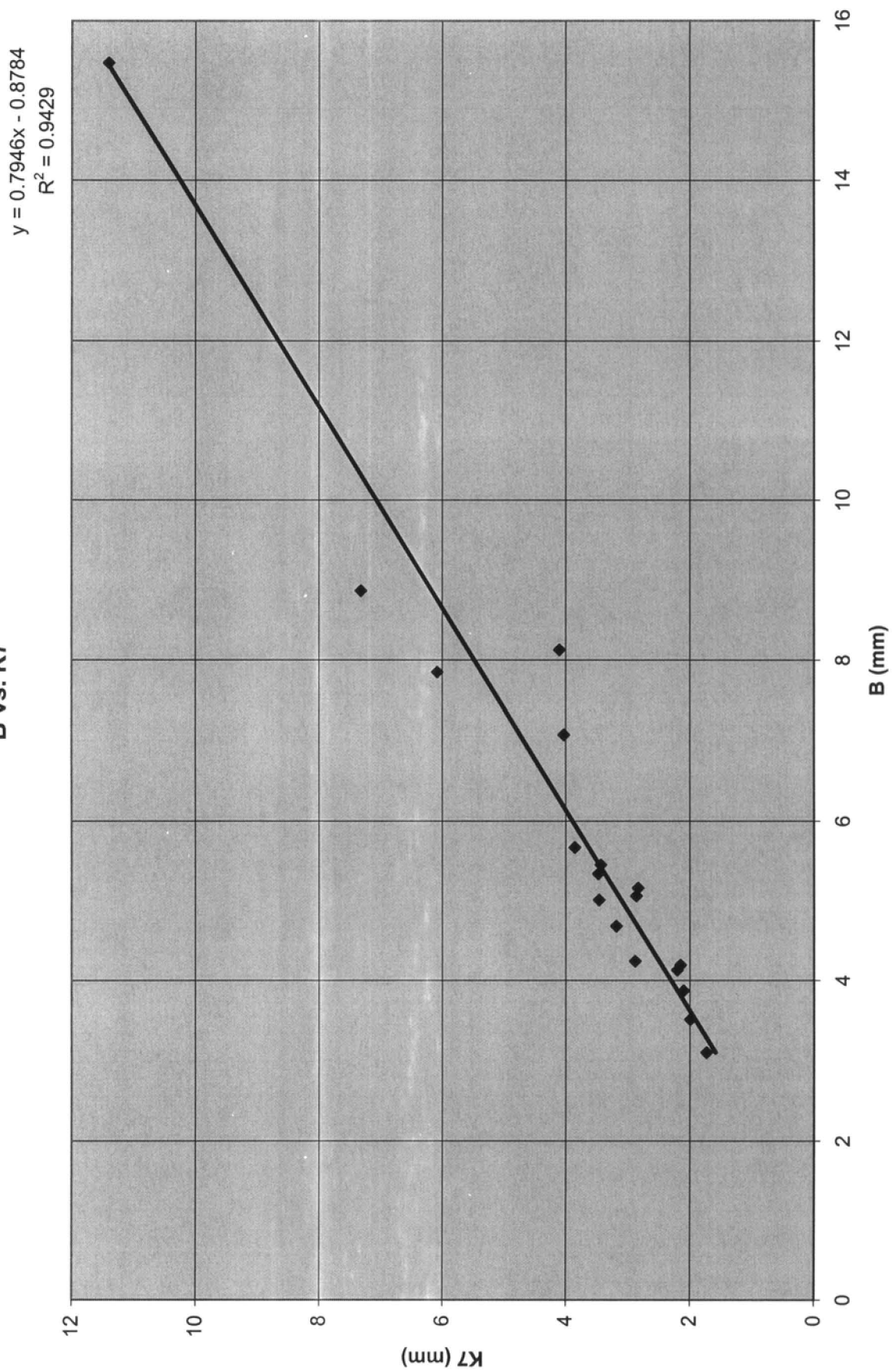


Figure 13

**B vs. K8**

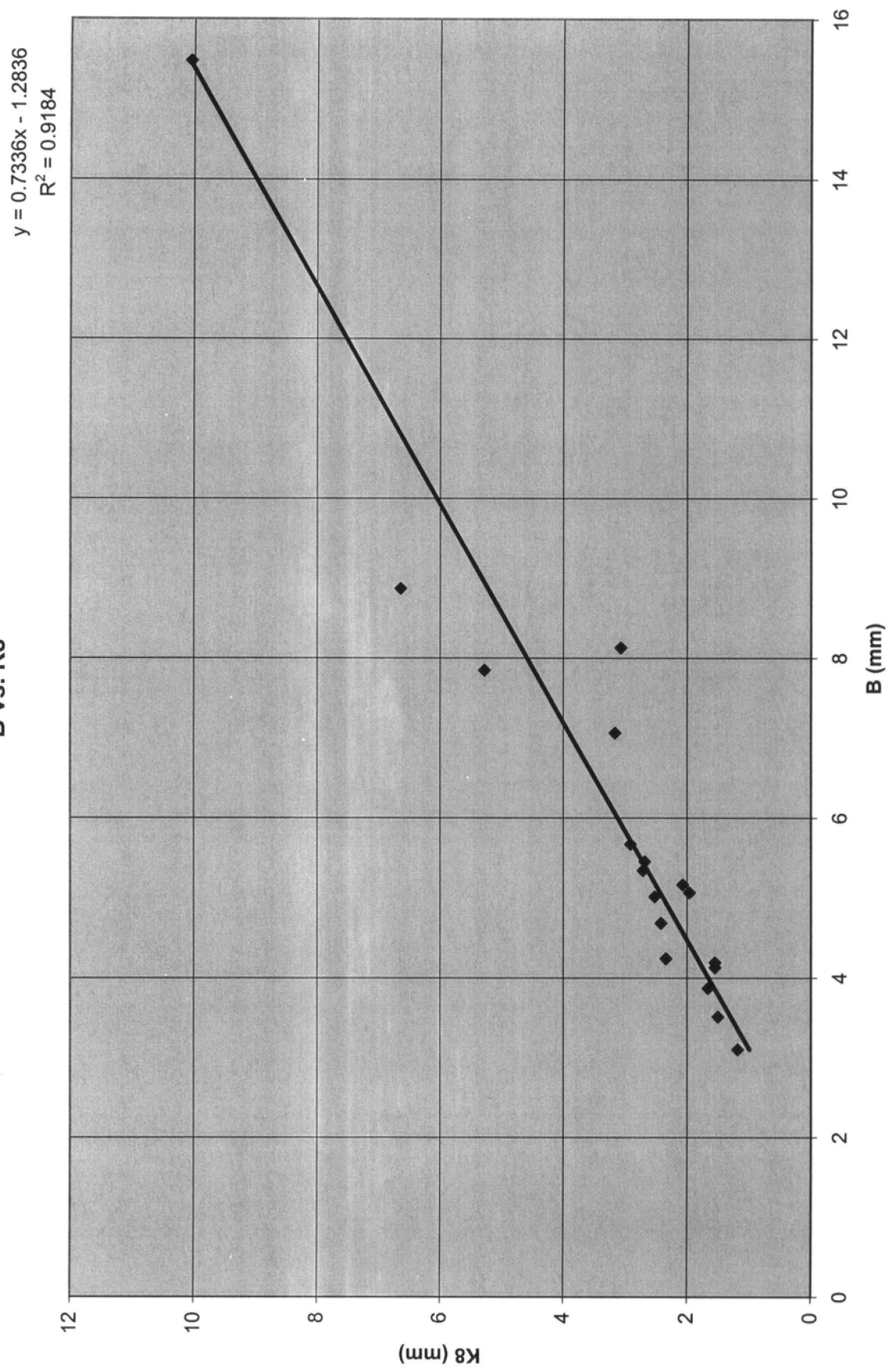


Figure 14

A vs. C

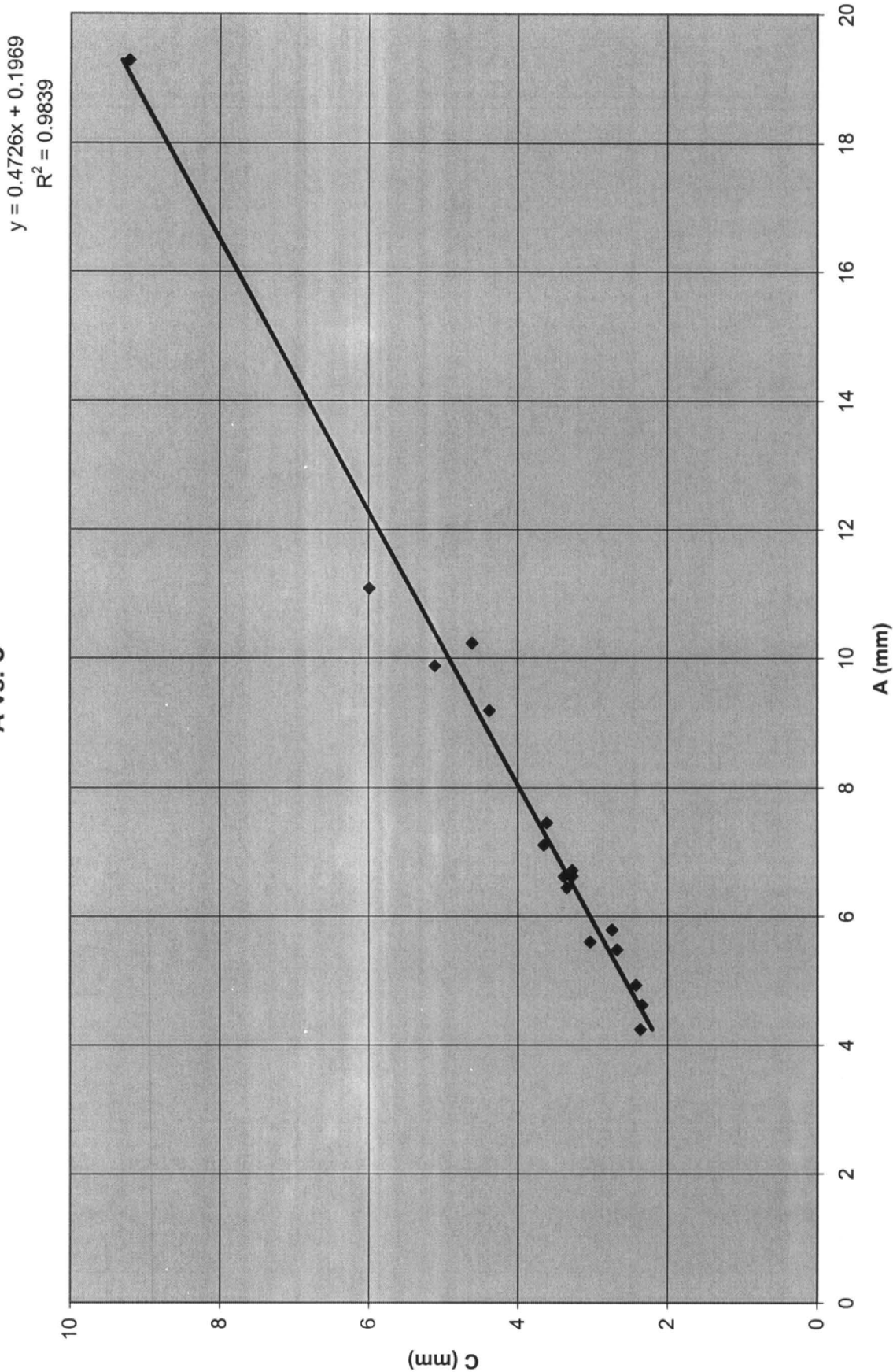


Figure 15

A vs. C1

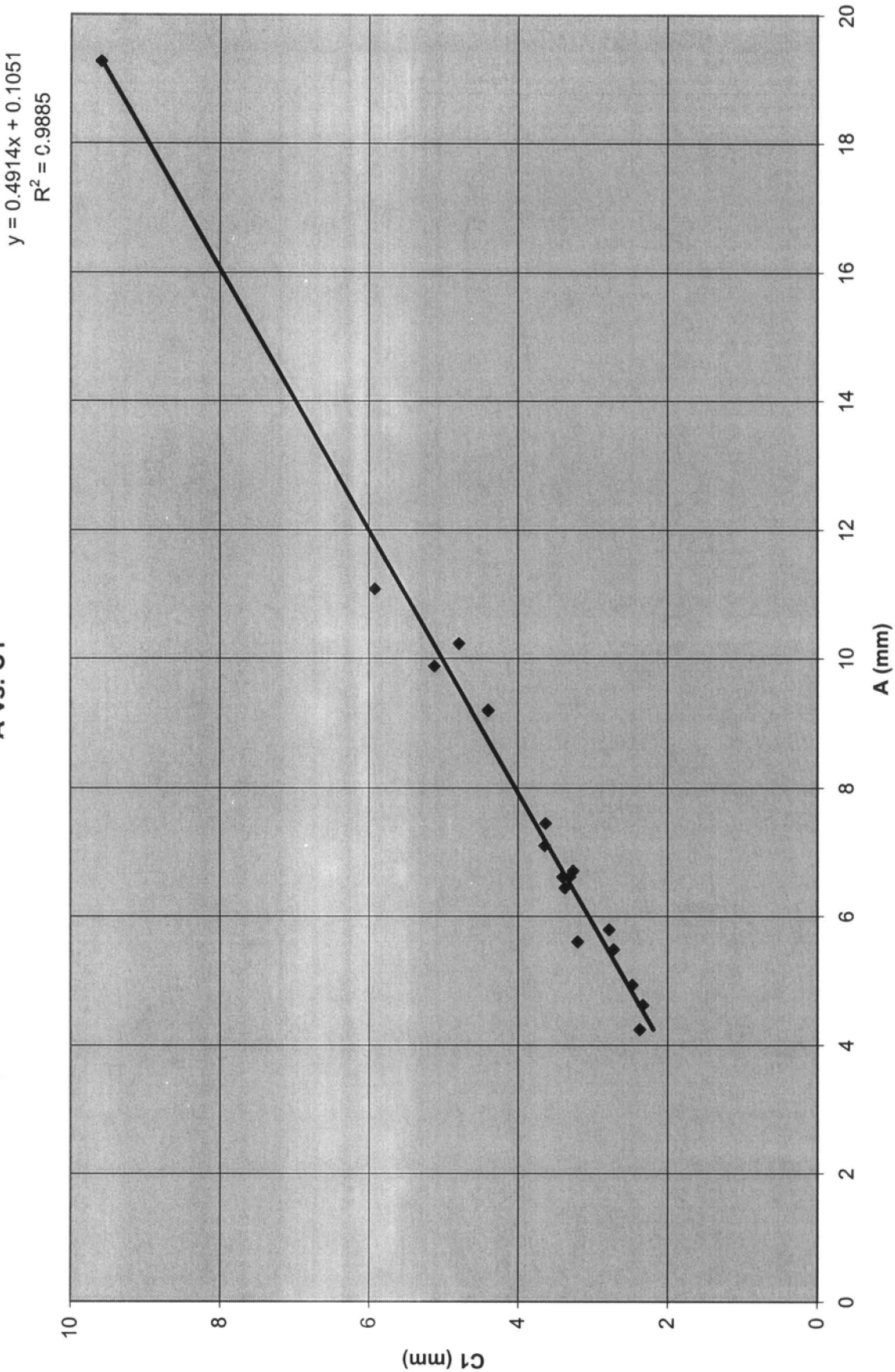




Figure 16

I2 vs. F

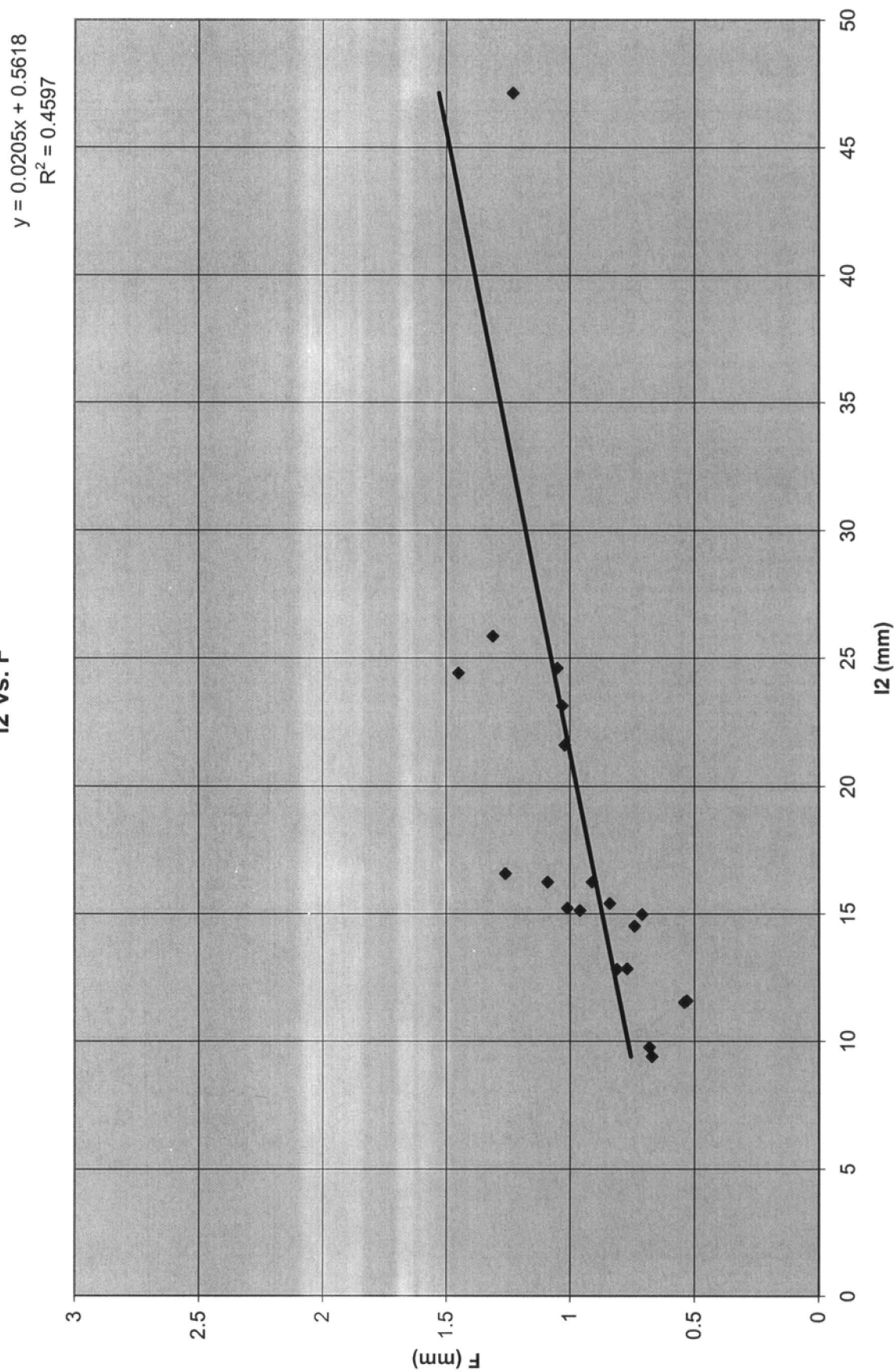


Figure 17

**A vs. B**

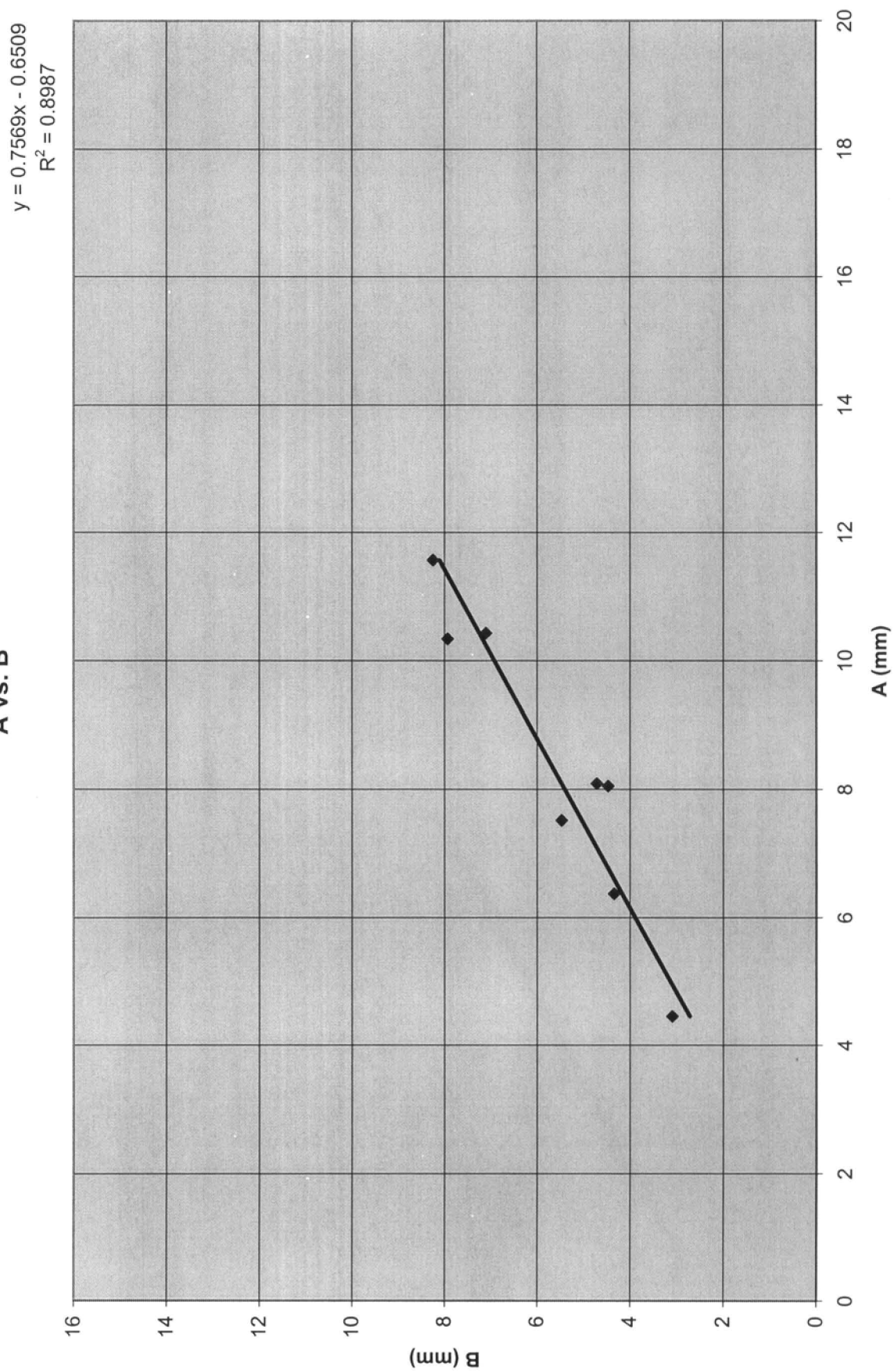


Figure 18

A vs. I2

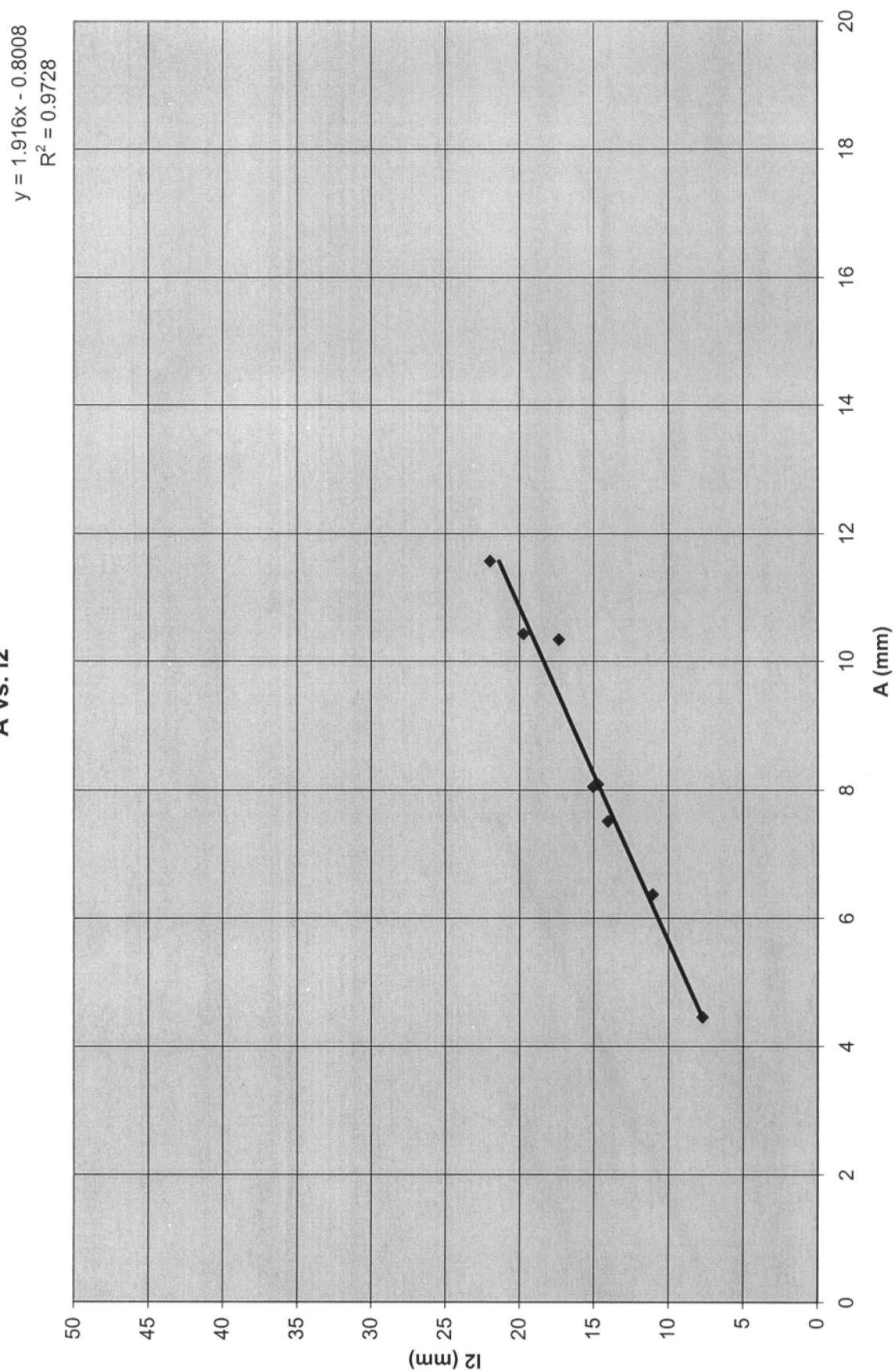


Figure 19

B vs. I2

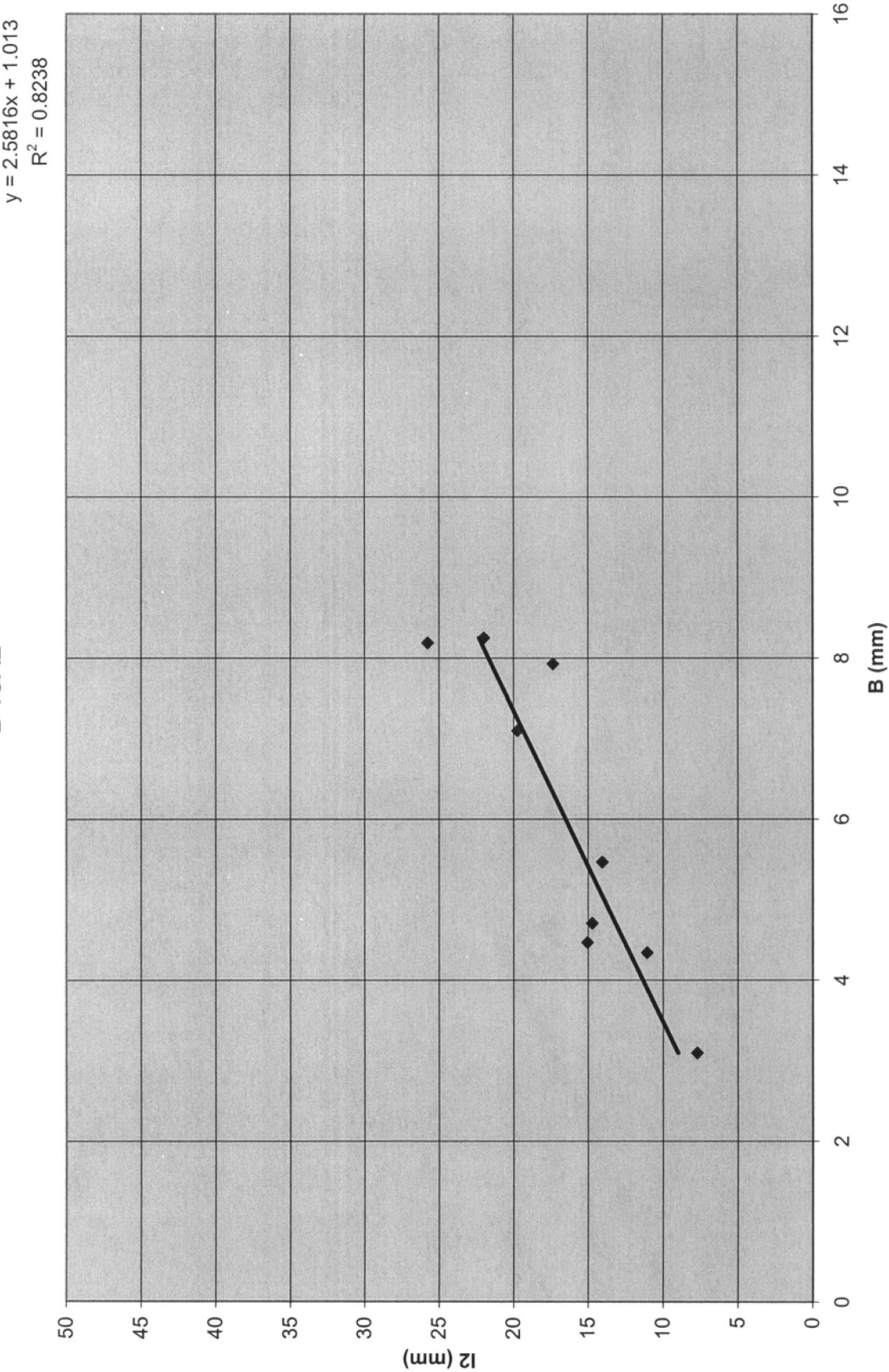




Figure 20

I2 vs. K6

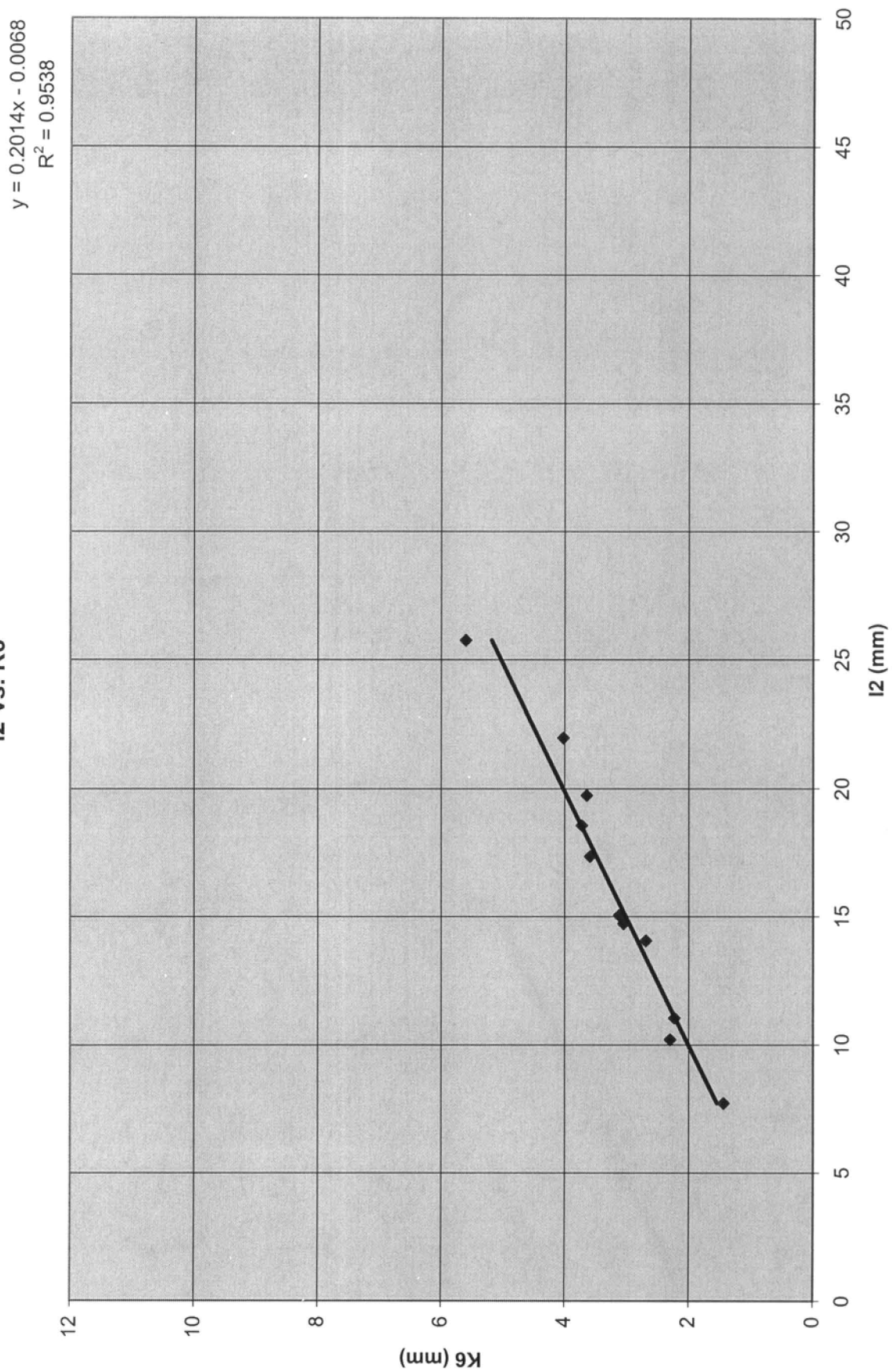


Figure 21

**B vs. K**

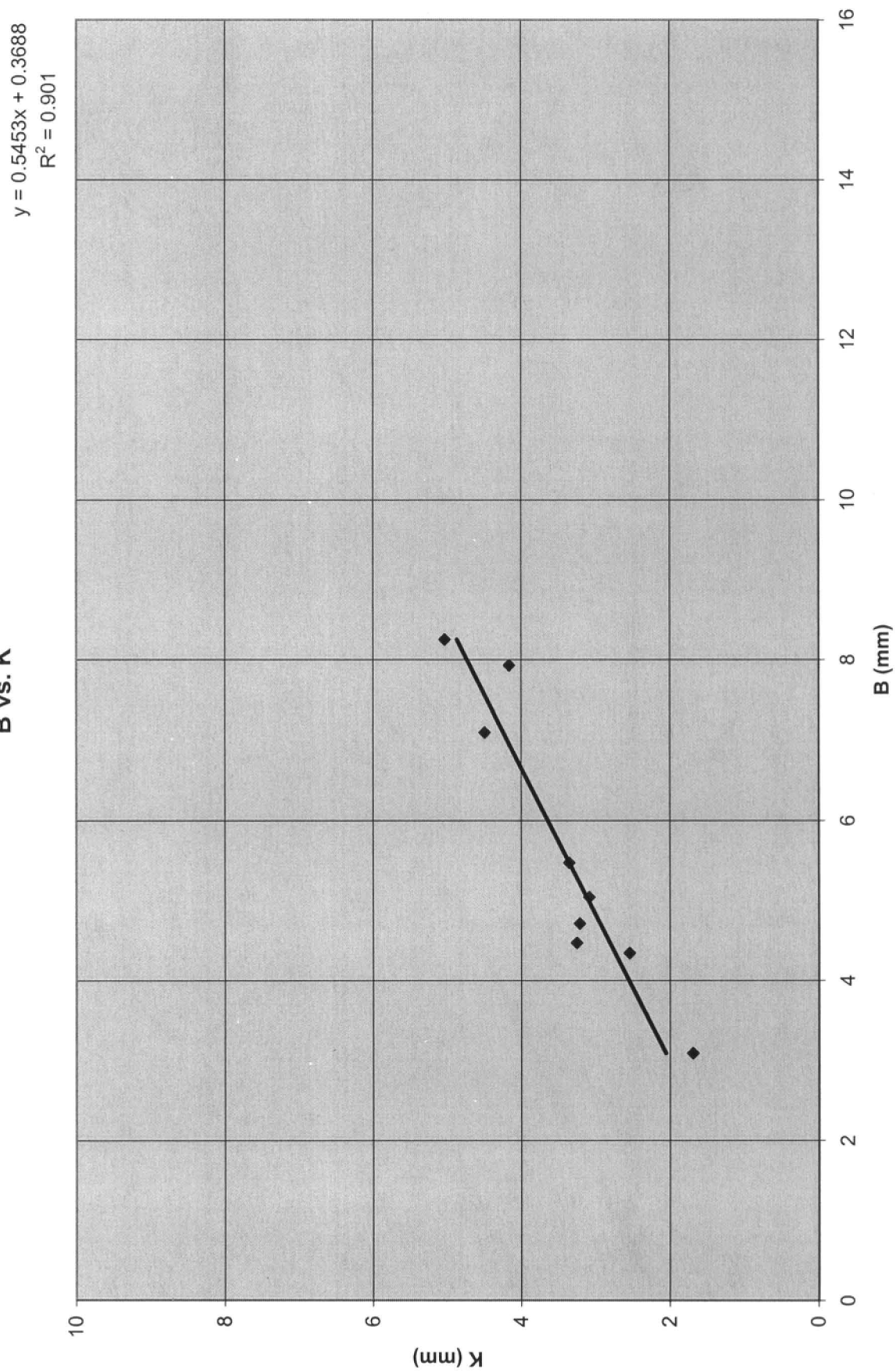


Figure 22

**B vs. K2**

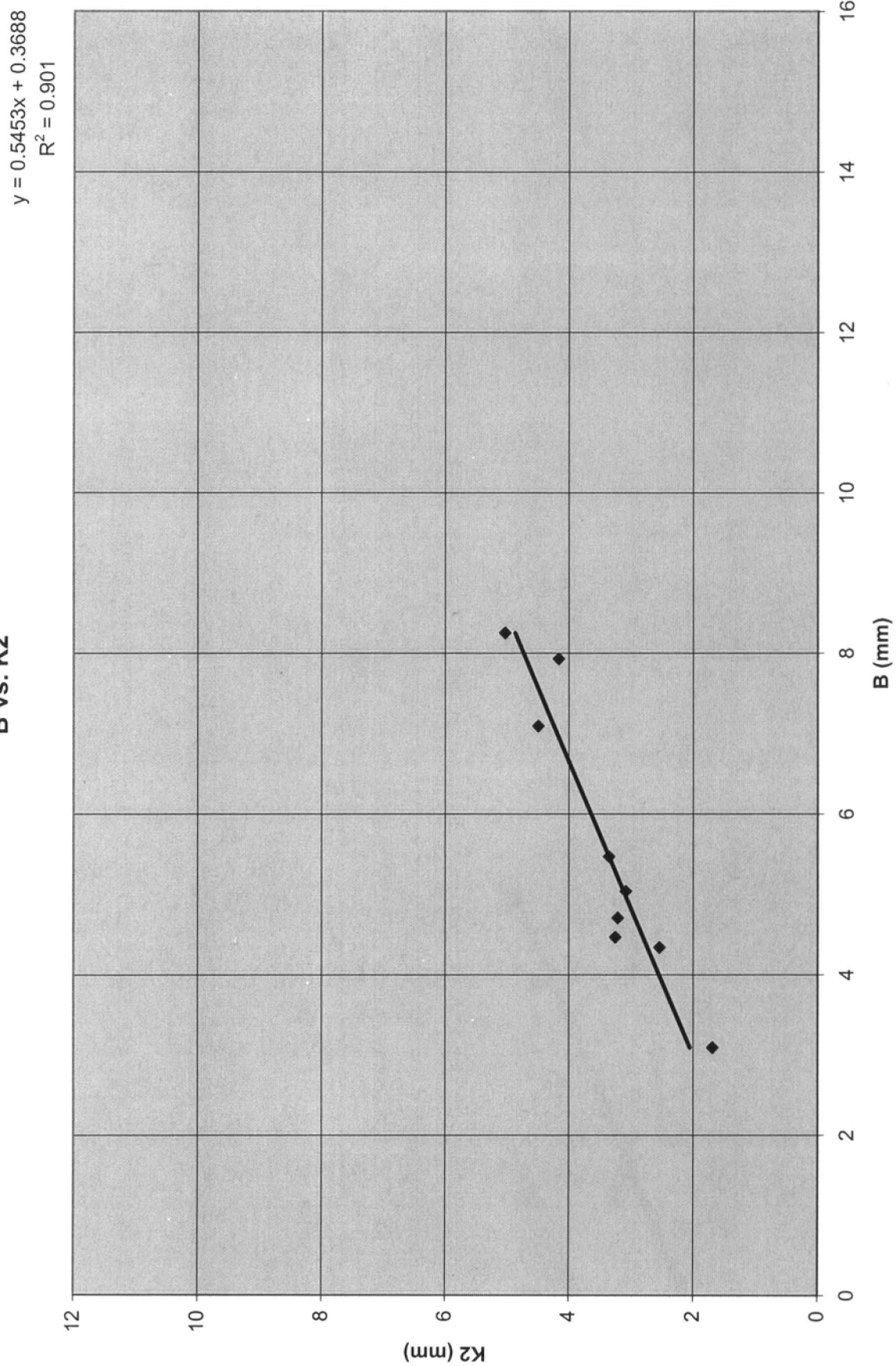


Figure 23

B vs. K3

$y = 0.7722x + 0.8328$   
 $R^2 = 1$

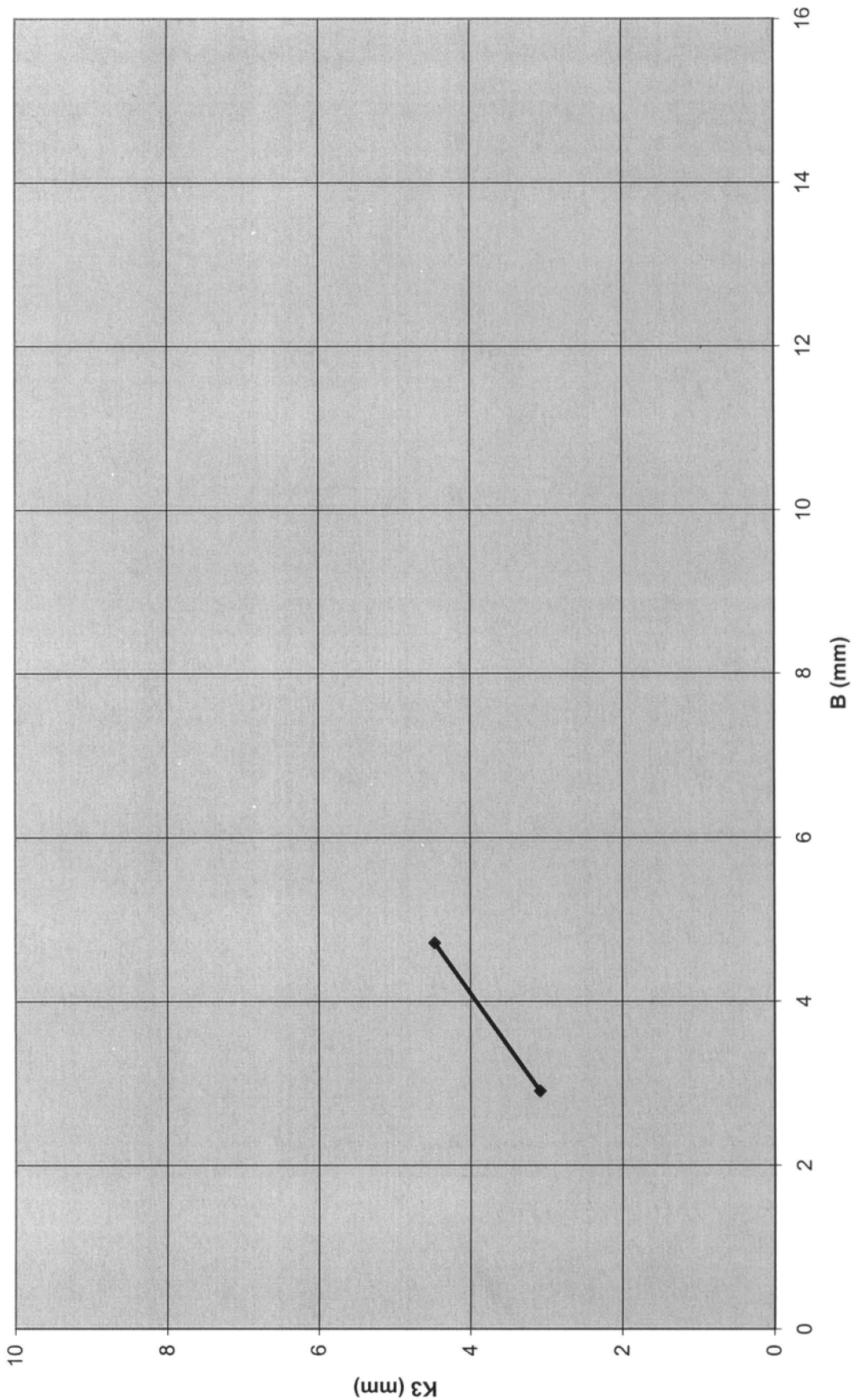




Figure 24

**B vs. K6**

$$y = 0.5244x + 0.1206$$
$$R^2 = 0.7401$$

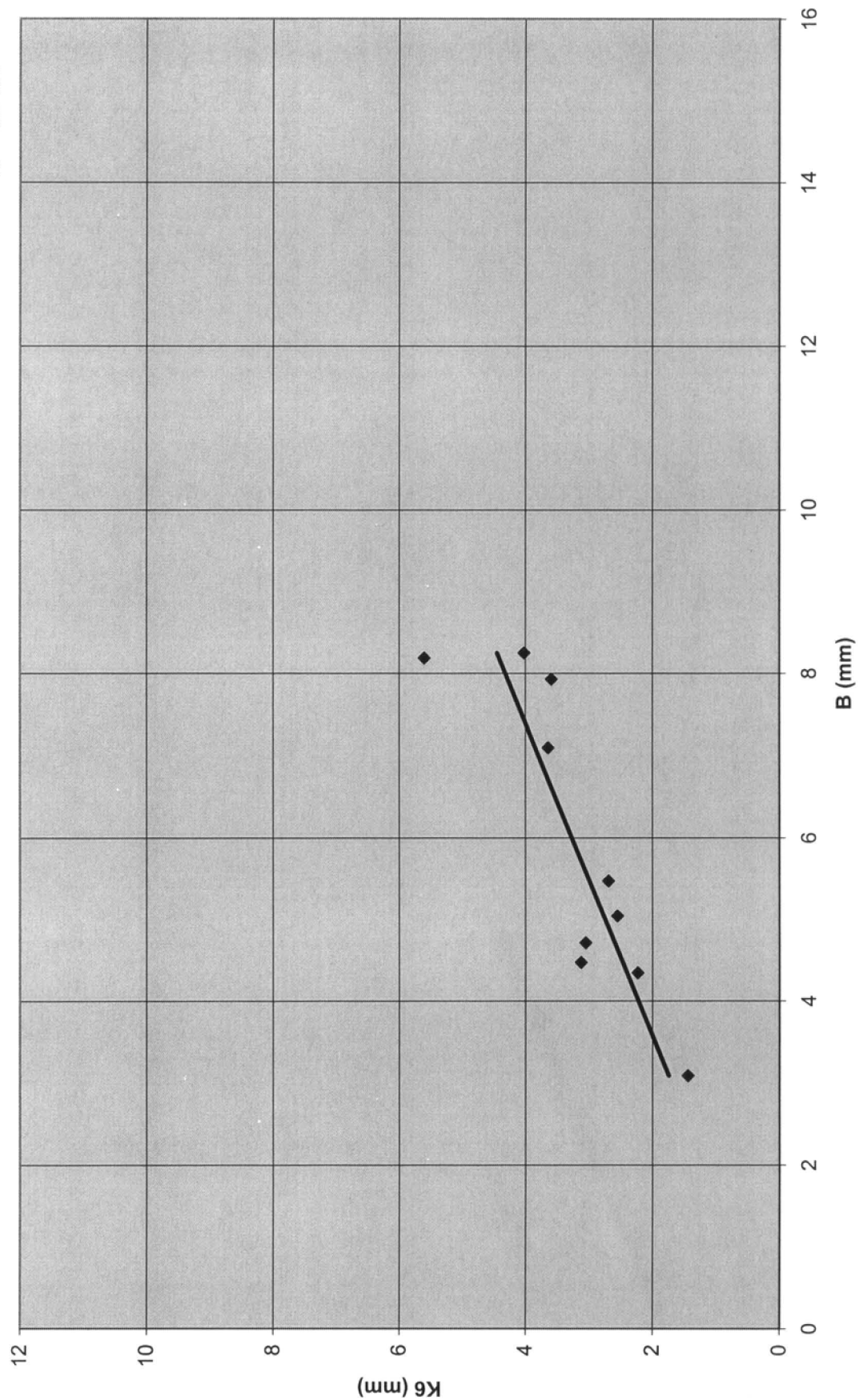


Figure 25

**B vs. K7**

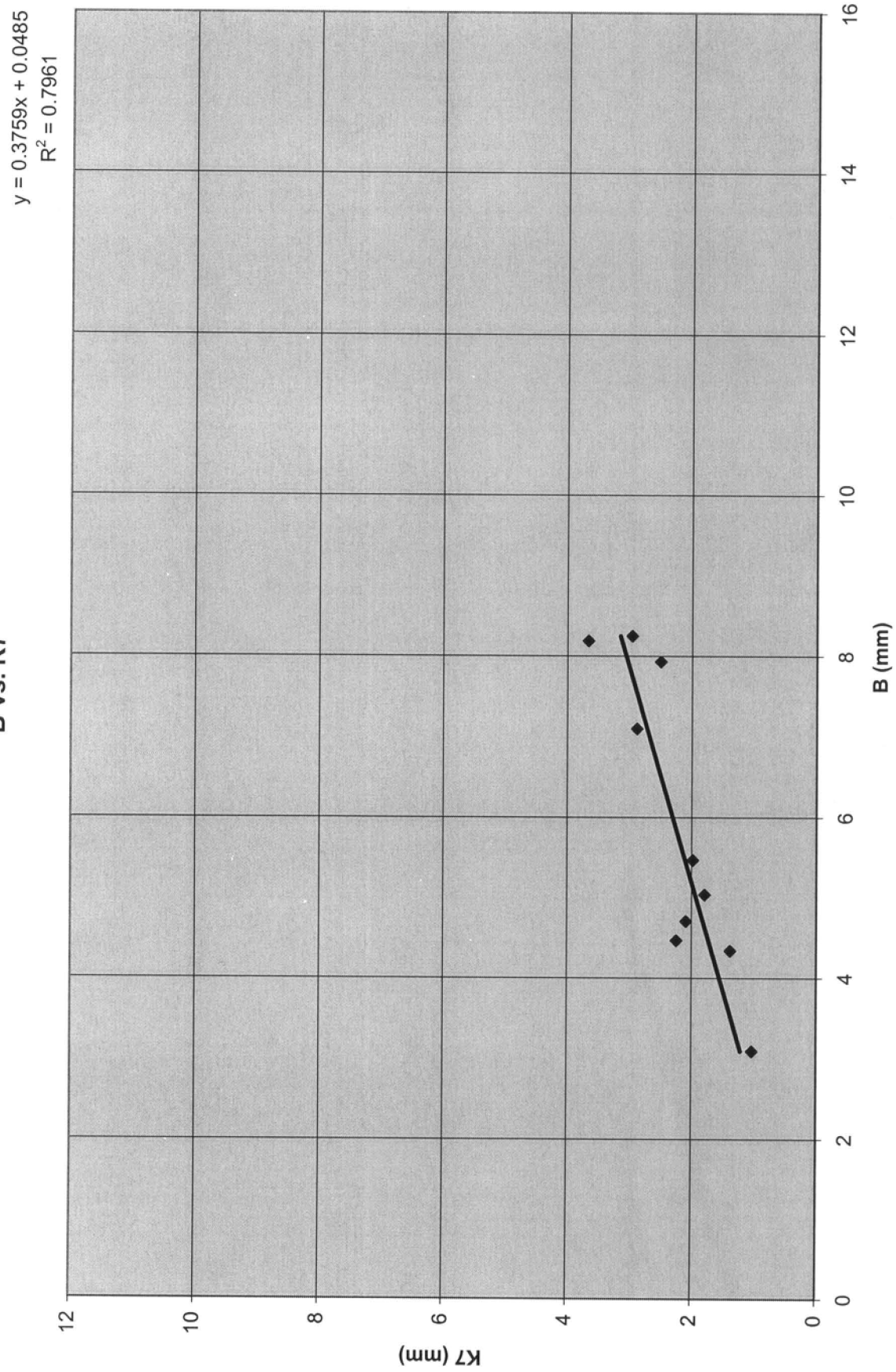


Figure 26

B vs. K8

$y = 0.245x + 0.0255$   
 $R^2 = 0.7291$

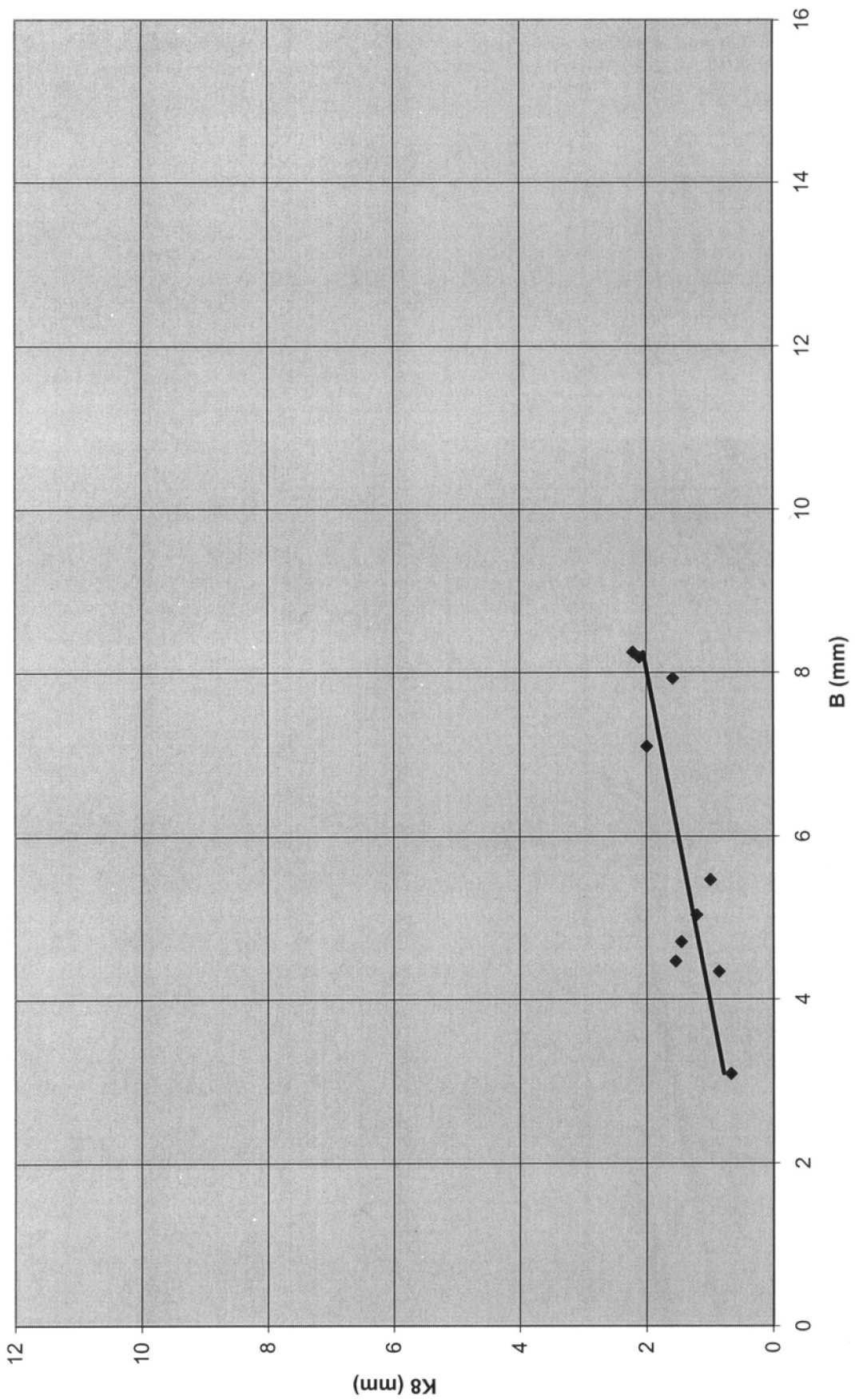


Figure 27

A vs. C

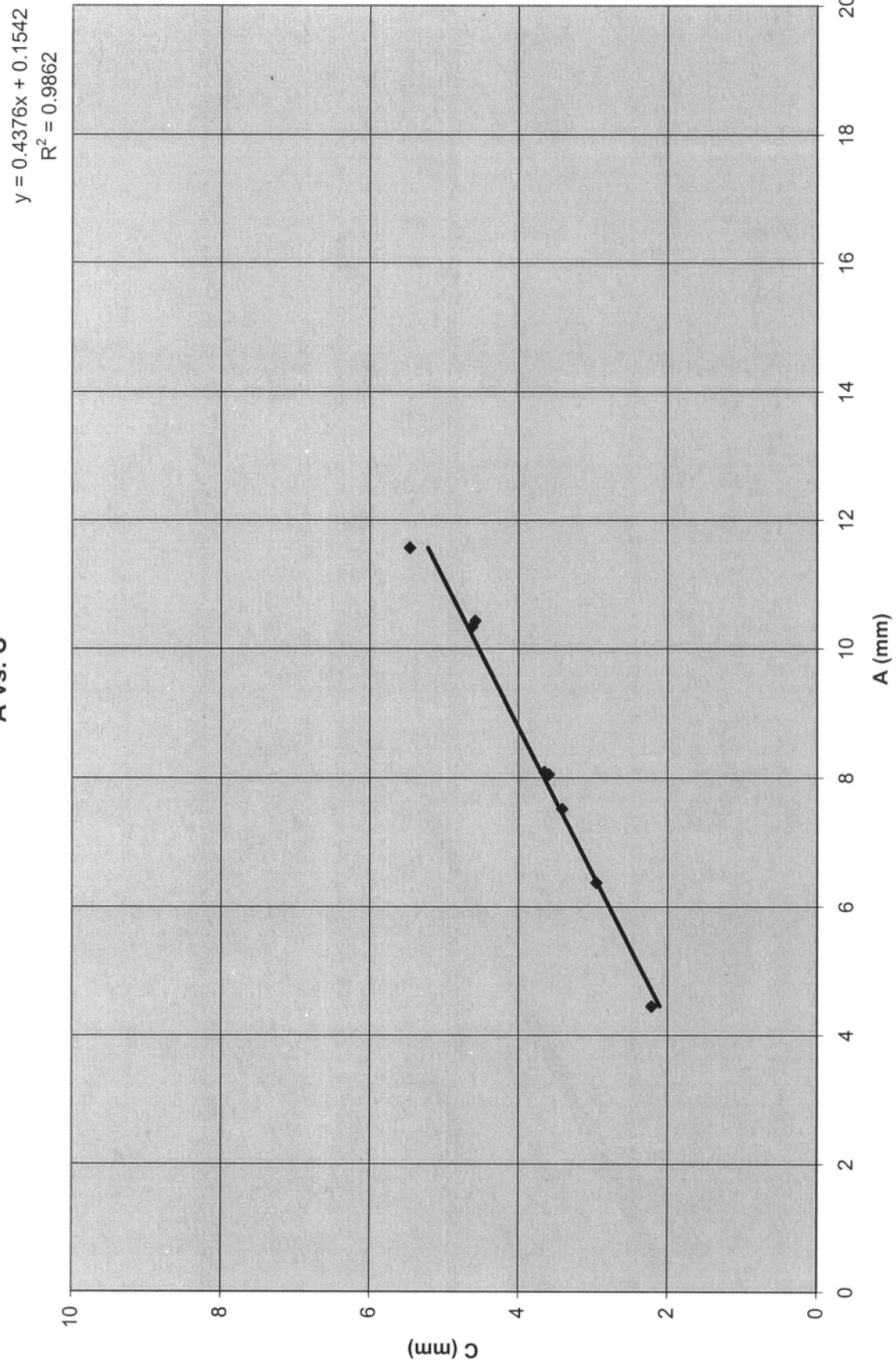




Figure 28

A vs. C1

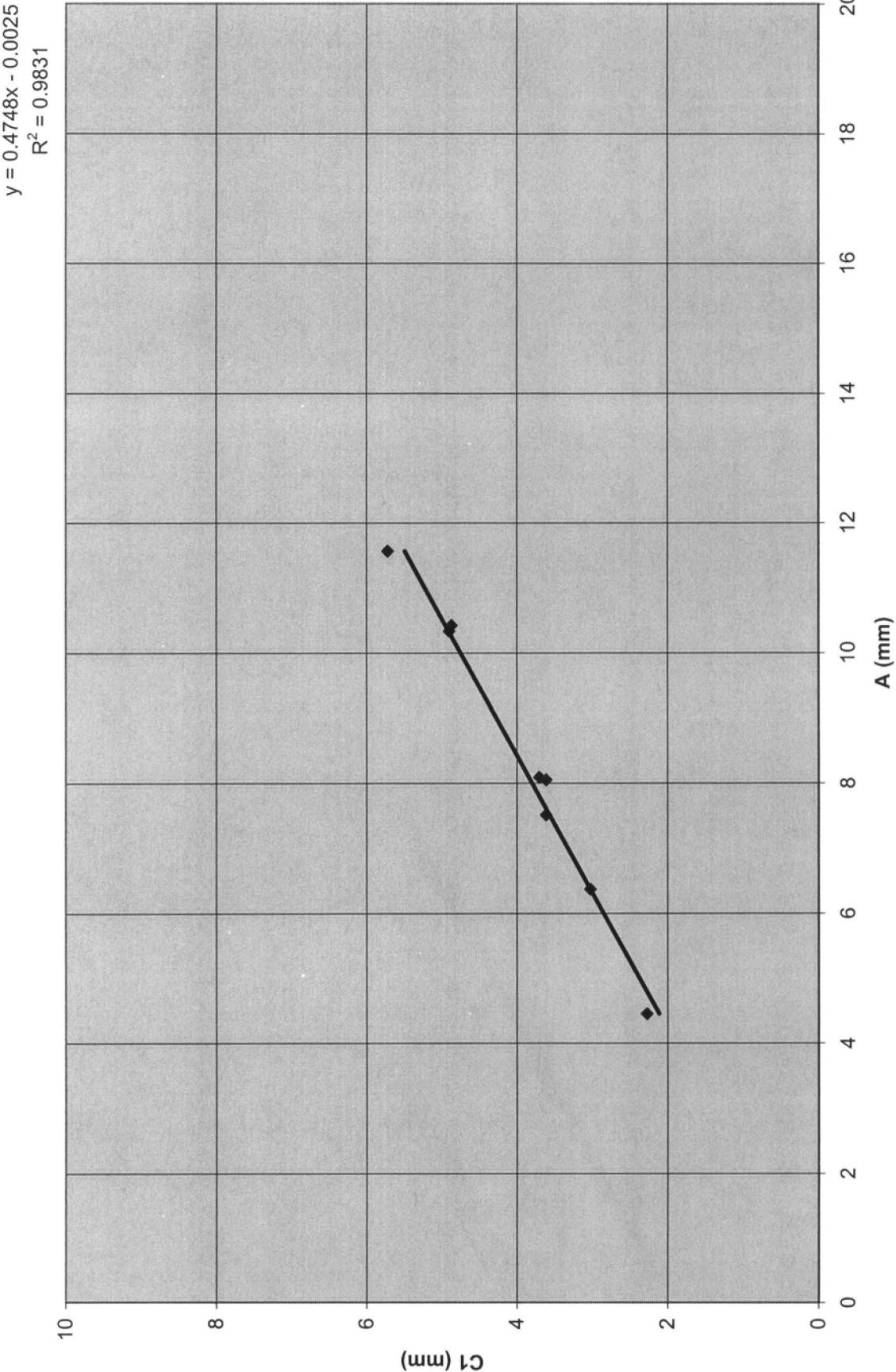


Figure 29

I2 vs. F

$$y = 0.0846x + 0.4734$$
$$R^2 = 0.3821$$

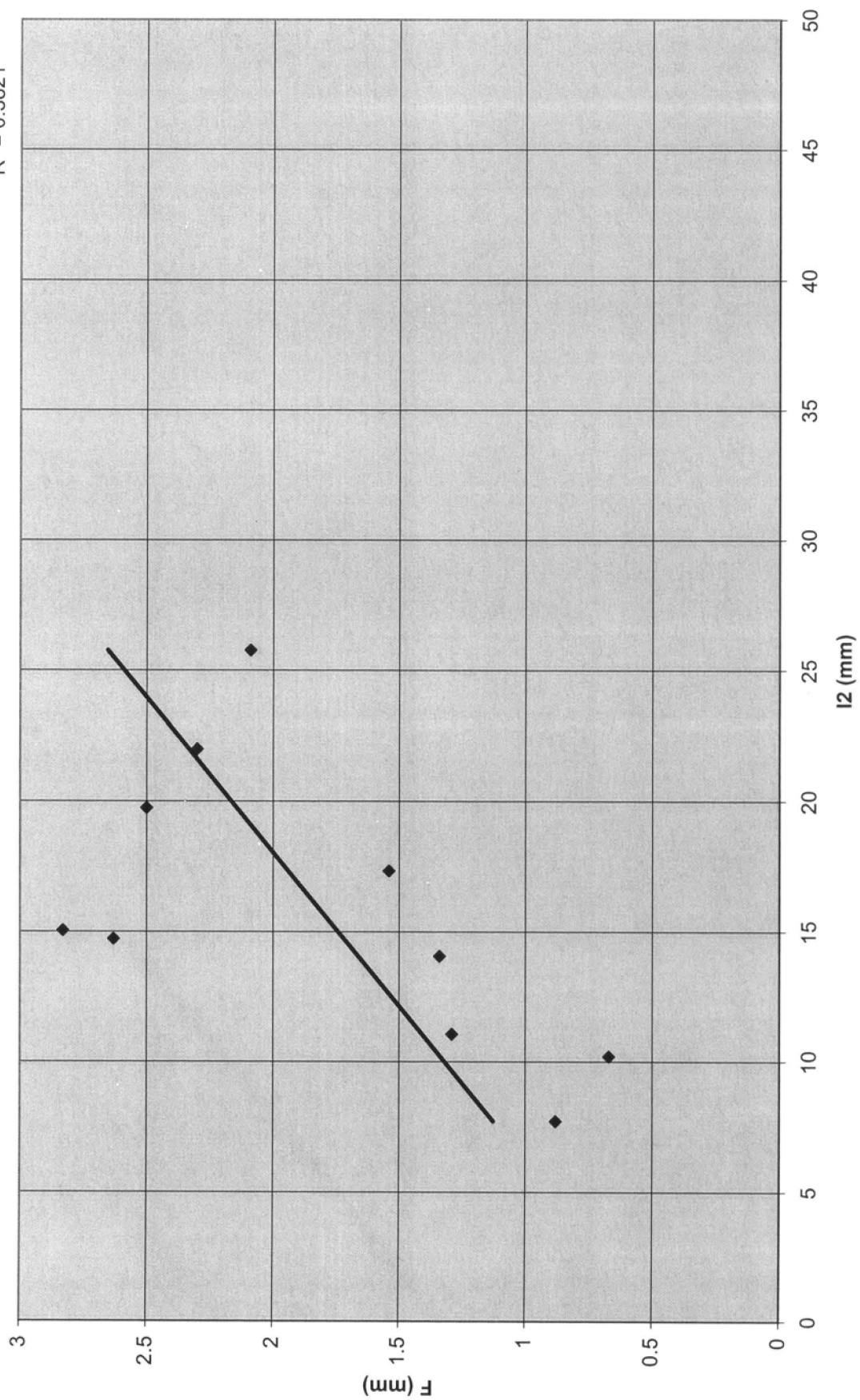


Figure 30

A vs. B

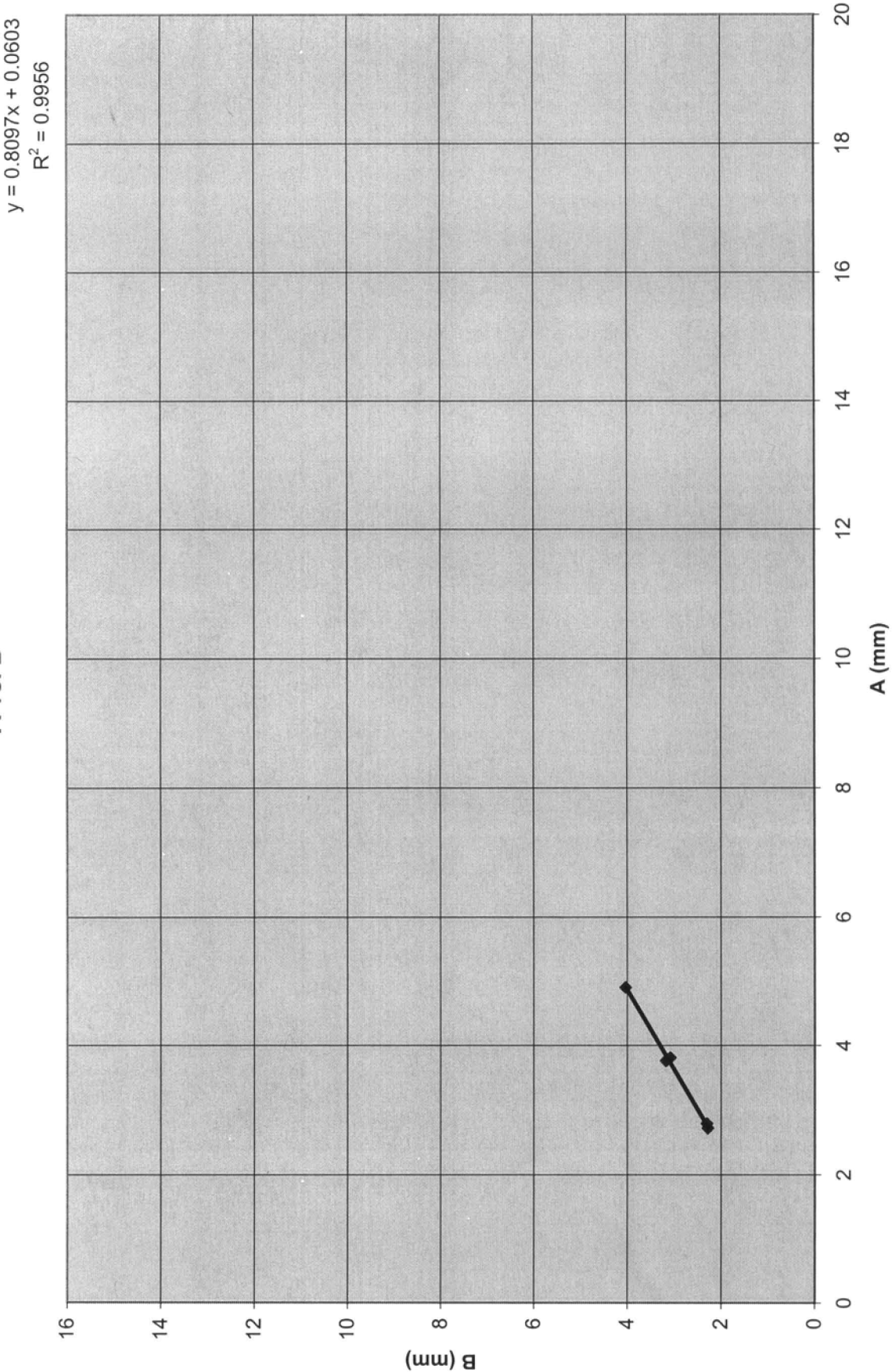


Figure 31

A vs. I2

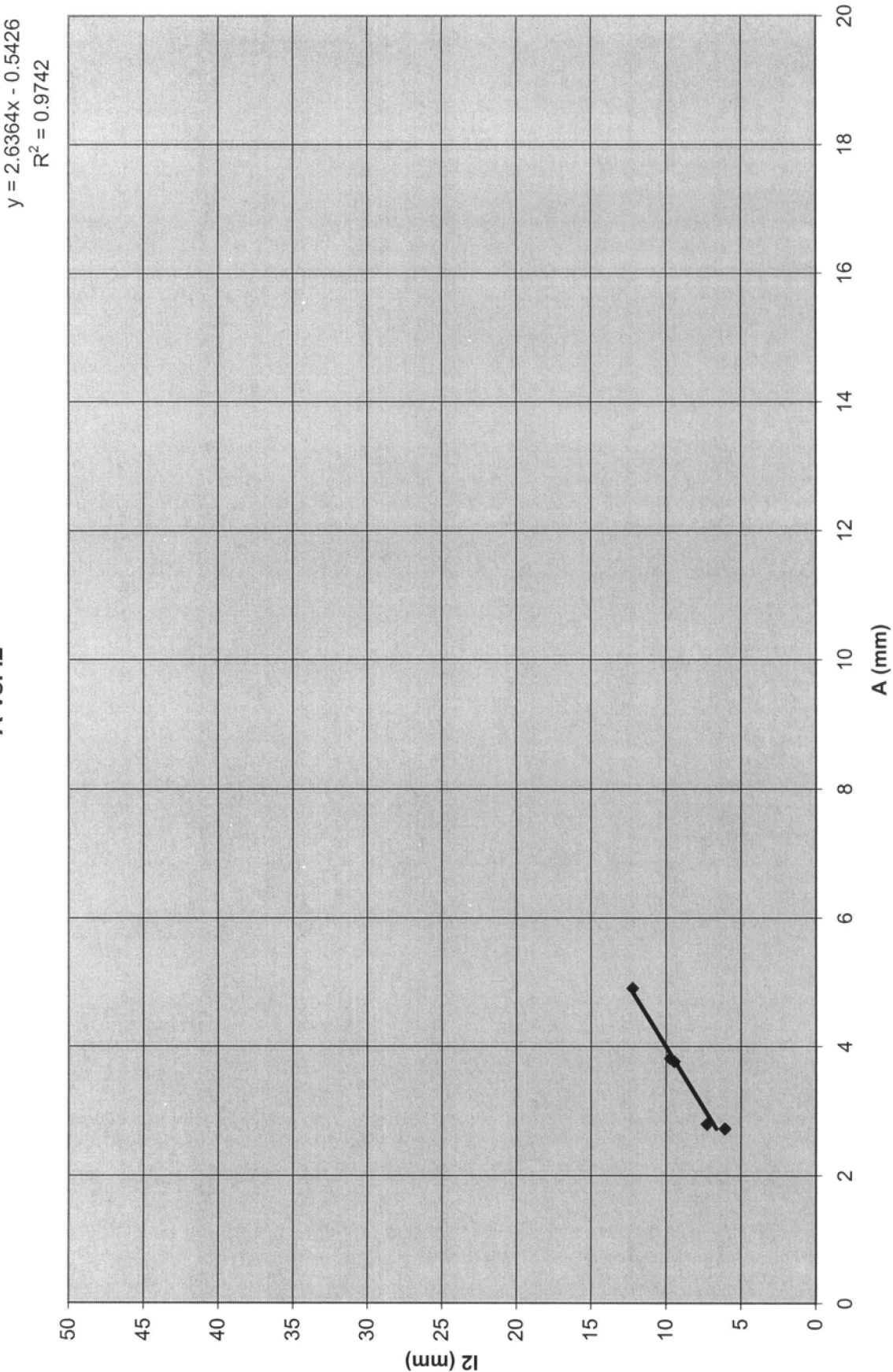




Figure 32

B vs. I2

$y = 3.229x - 0.6585$   
 $R^2 = 0.9622$

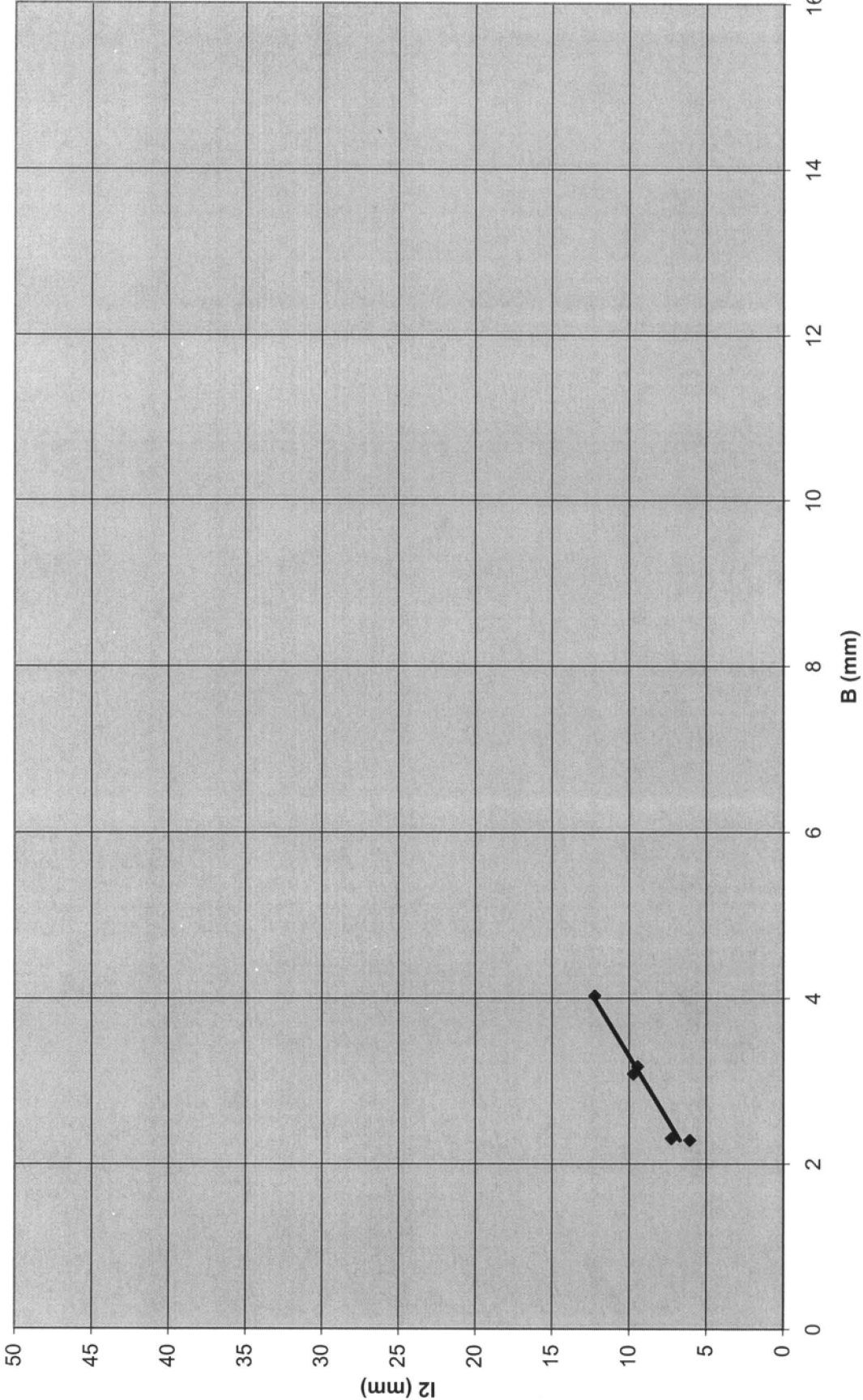


Figure 33

I2 vs. K6

$y = 0.2756x - 0.3721$   
 $R^2 = 0.925$

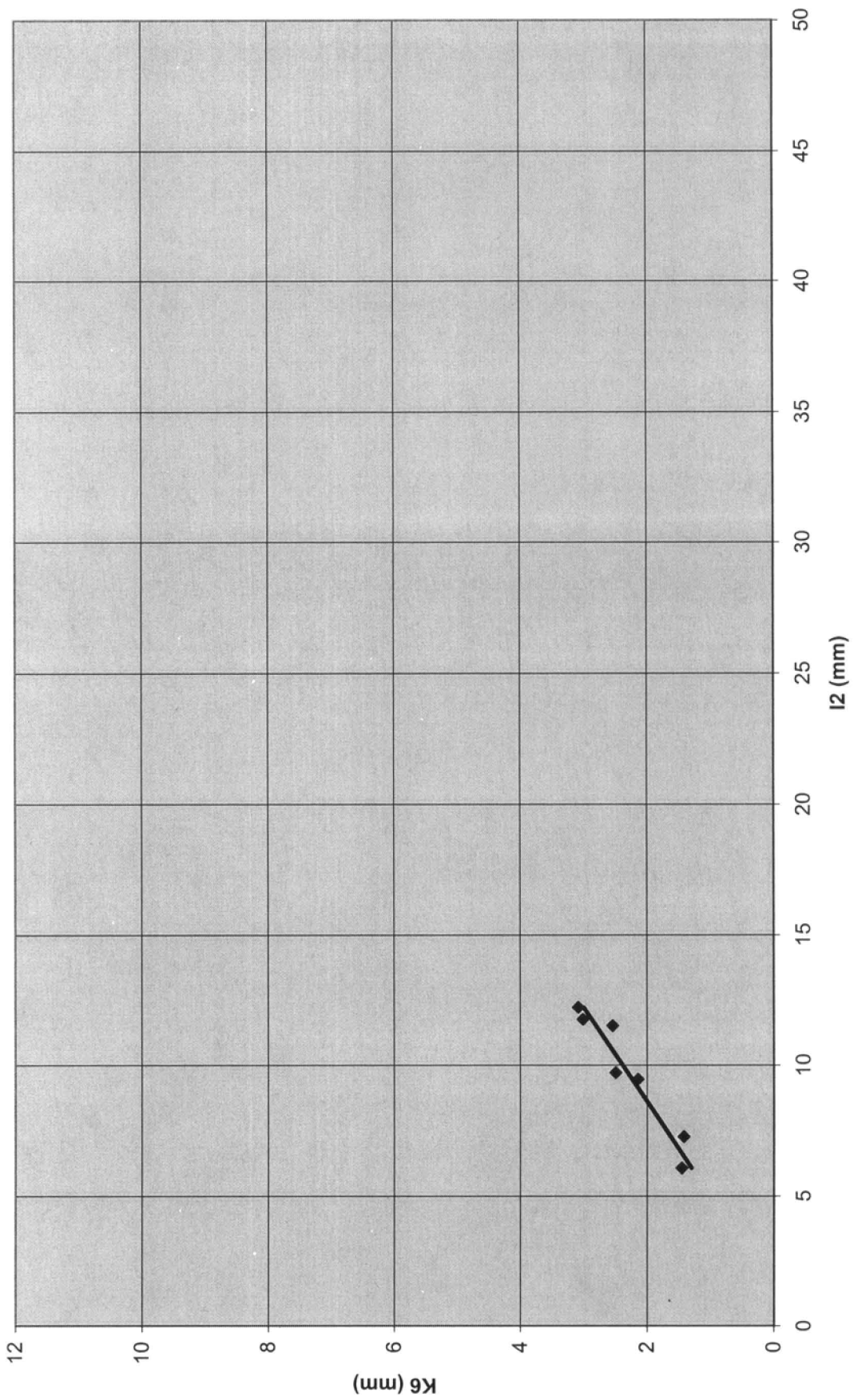


Figure 34

**B vs. K**

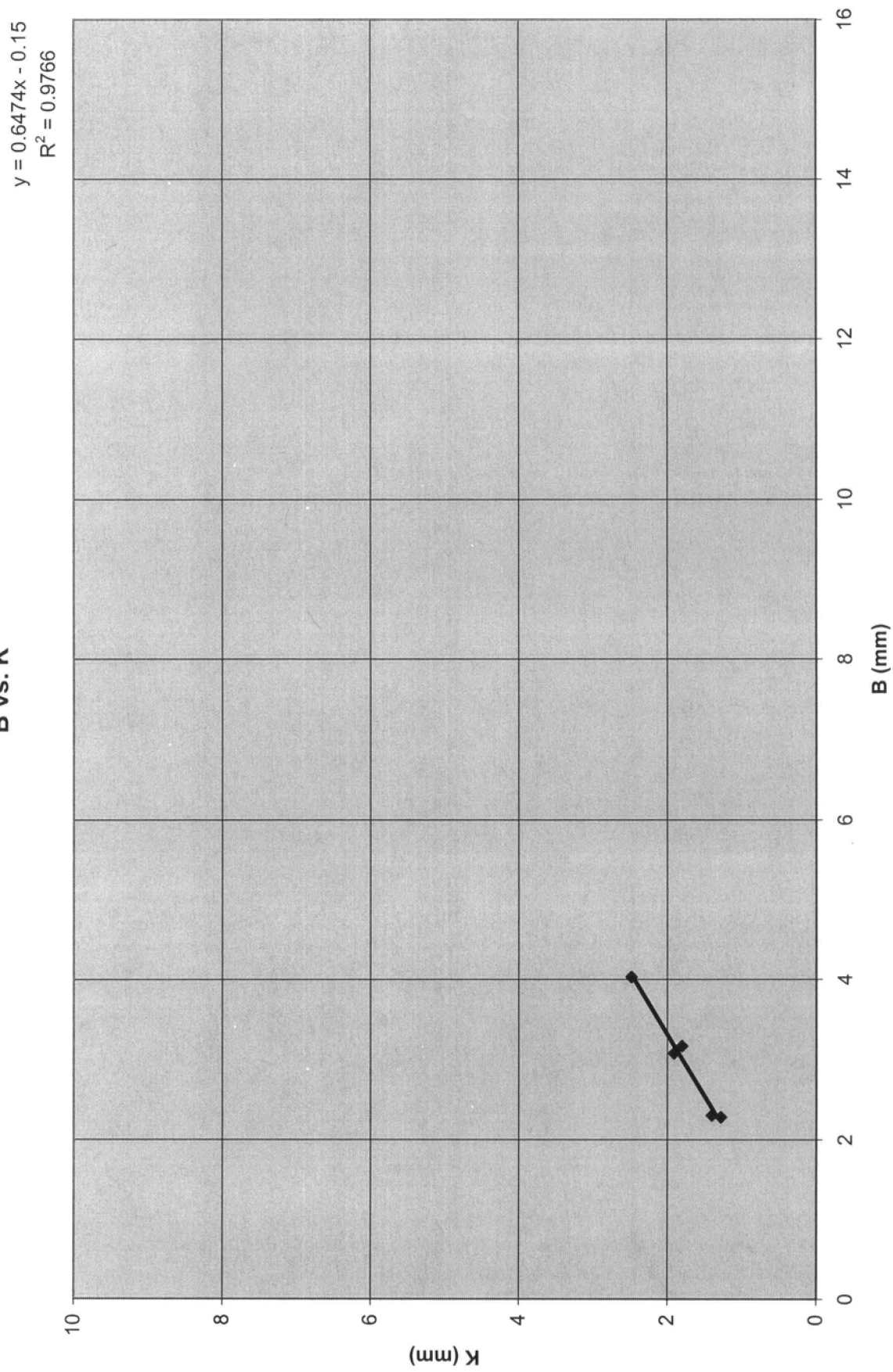


Figure 35

B vs. K2

$y = 1.0837x - 0.4628$   
 $R^2 = 0.9385$

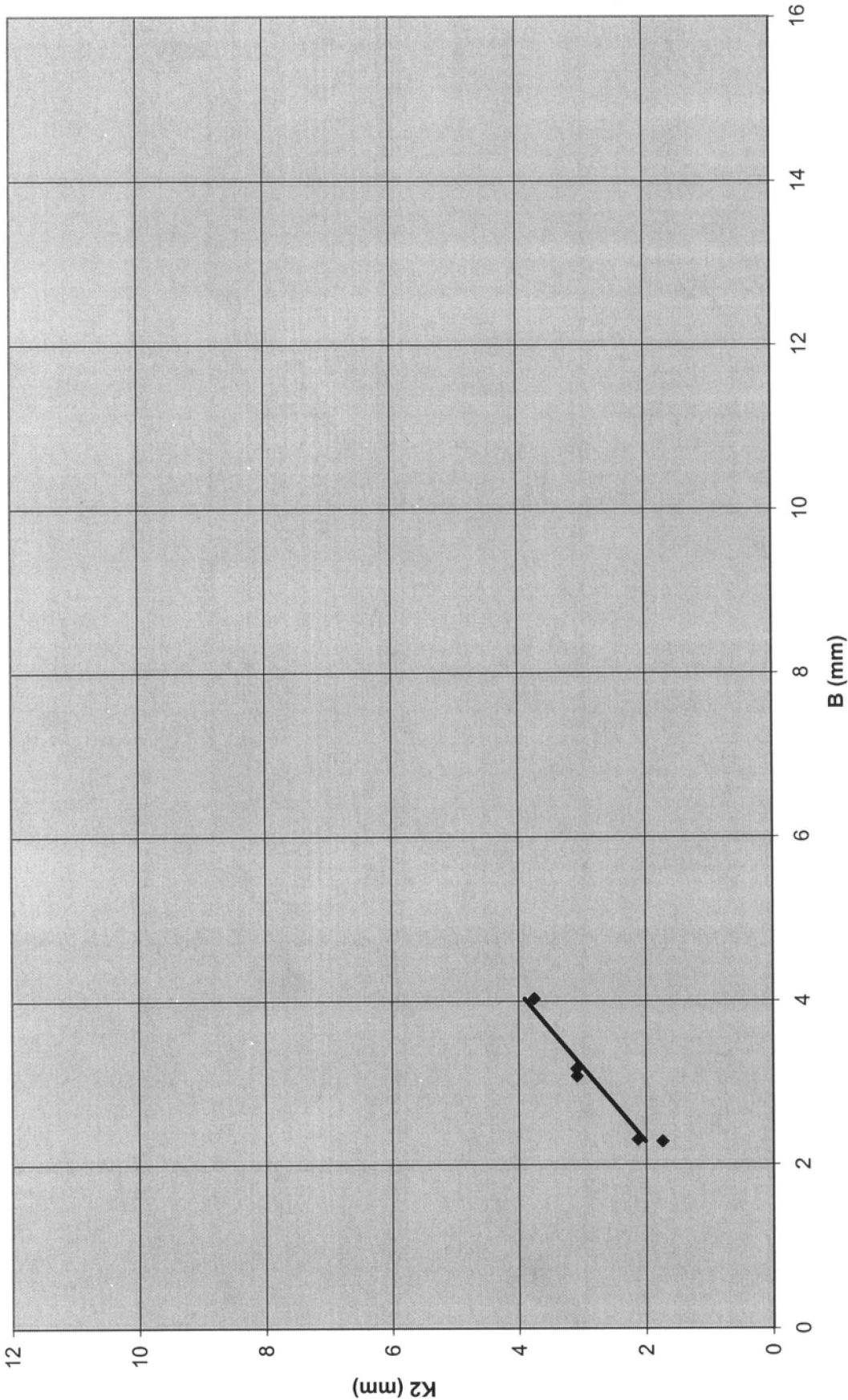




Figure 36

B vs. K6

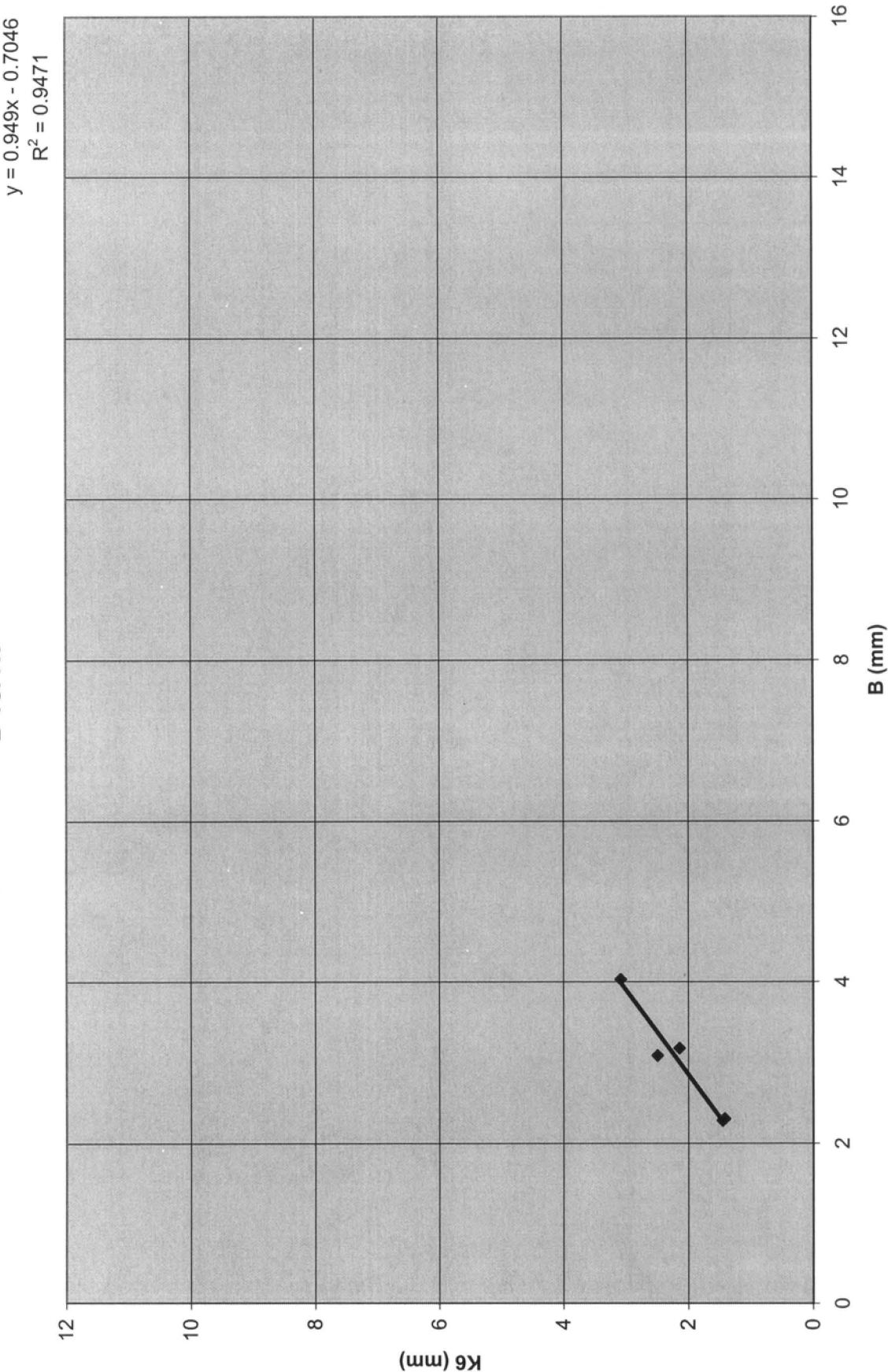


Figure 37

**B vs. K7**

$$y = 0.9975x - 0.2405$$
$$R^2 = 0.9506$$

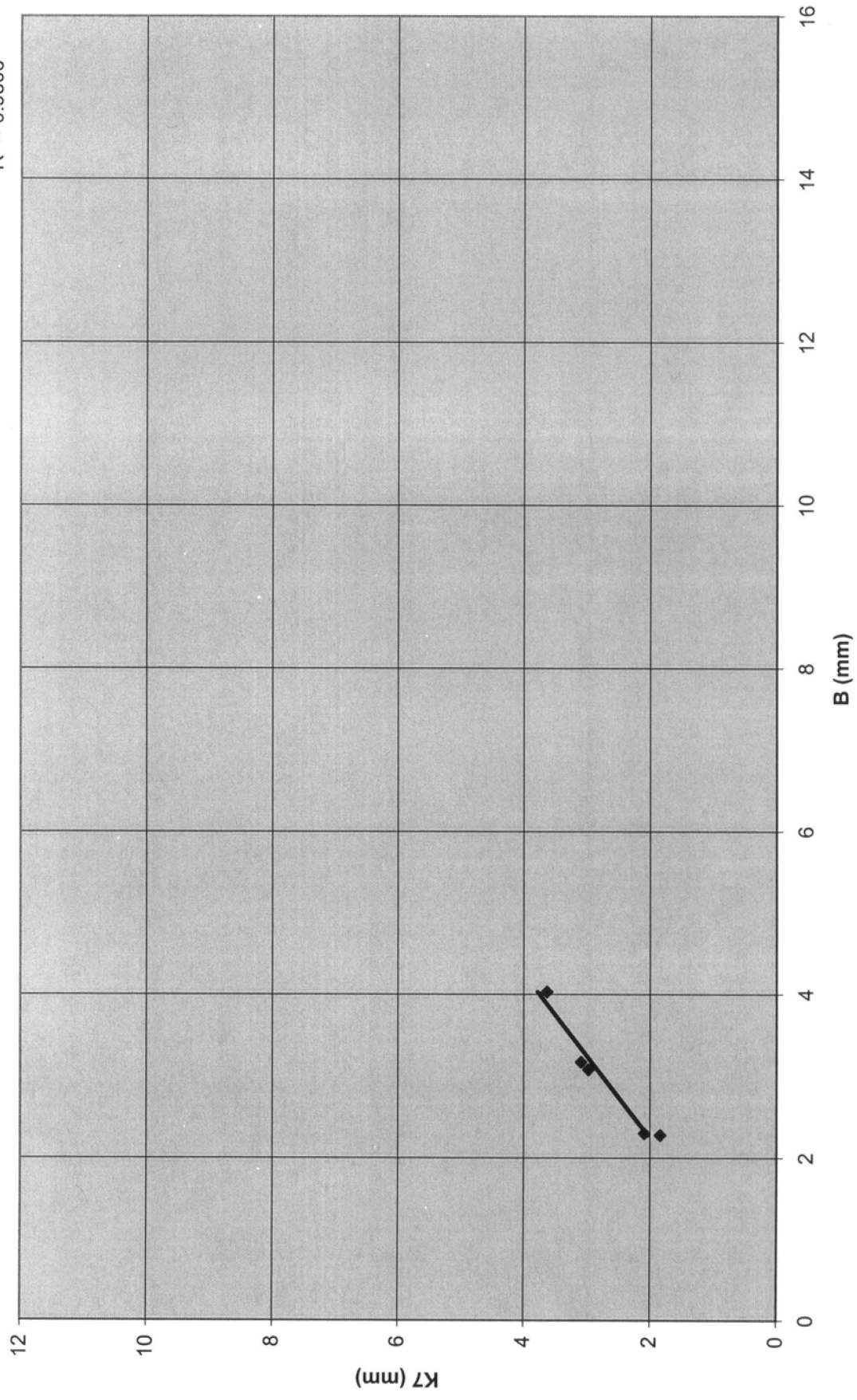


Figure 38

**B vs. K8**

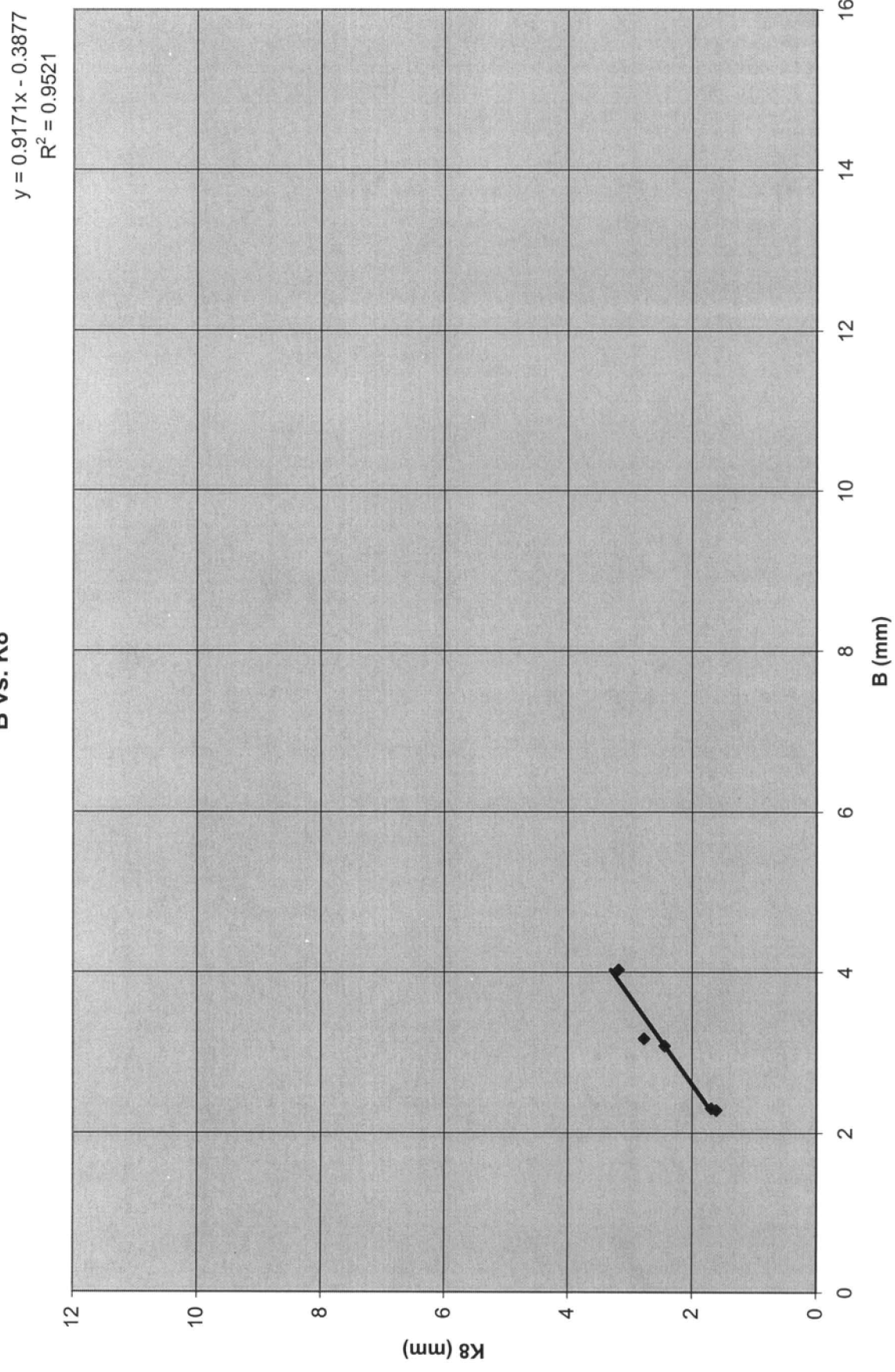


Figure 39

A vs. C

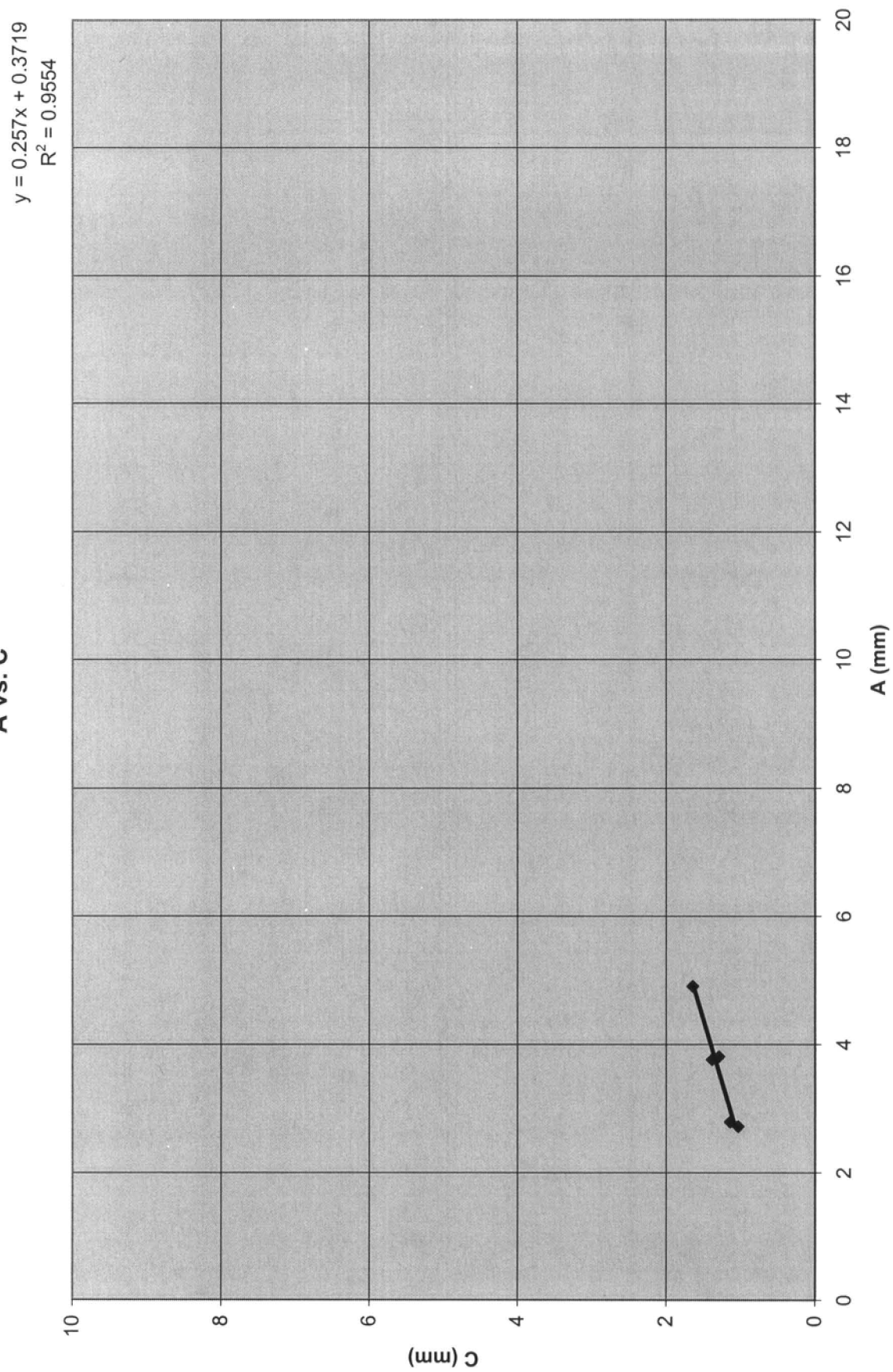


Figure 40

A vs. C1

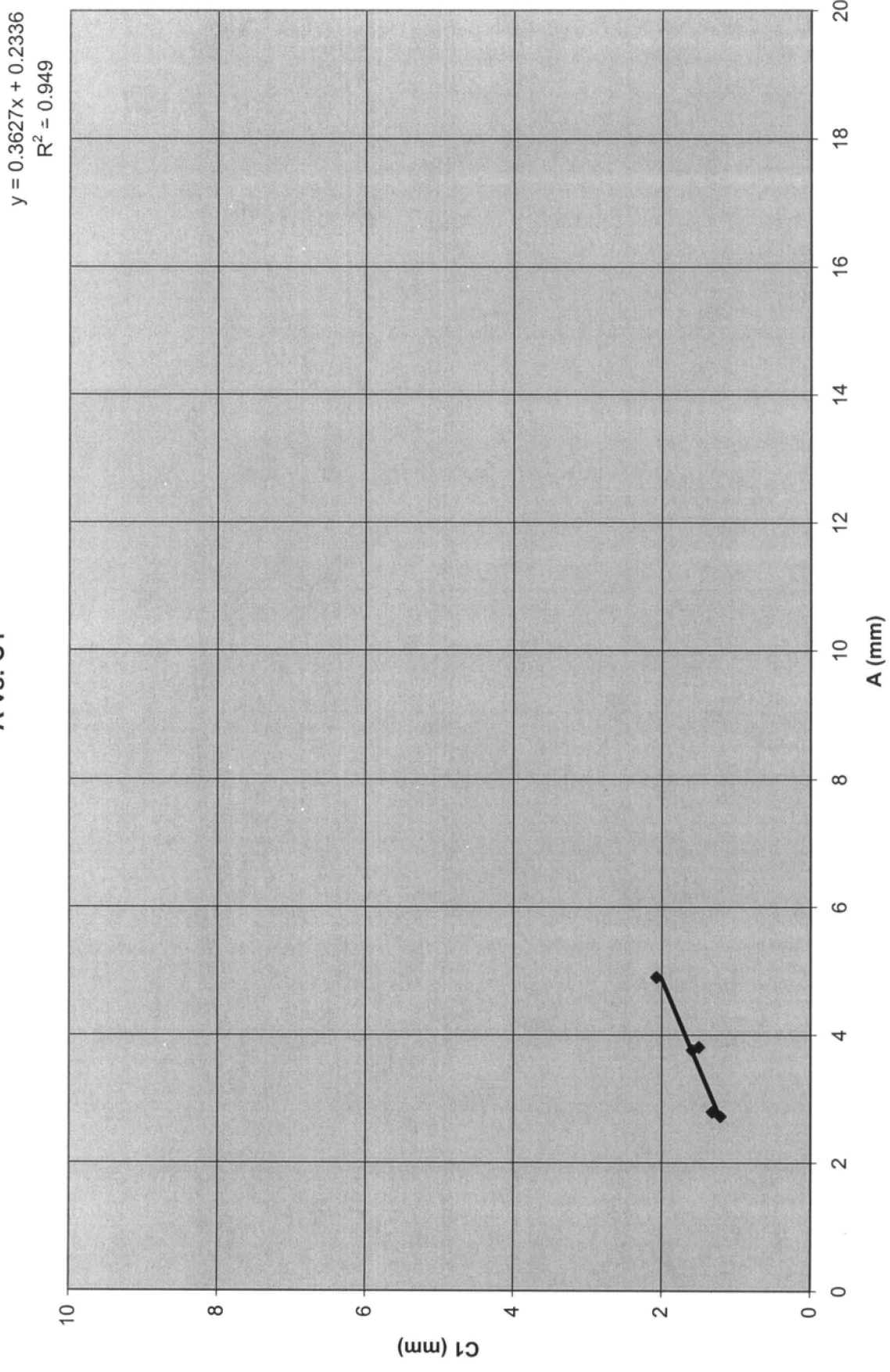




Figure 41

I2 vs. F

$y = 0.0315x - 0.0812$   
 $R^2 = 0.7888$

